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## Editorial

### THOROUGHNESS IN DIAGNOSIS

CALEB HILLIER PARRY, first to describe hyperthyroidism, spoke to his students as follows: "There is one malady which I have in five cases seen coincident with what appeared to be enlargement of the heart, and which, so far as I know, has not been noticed, in that connection, by medical writers. This malady to which I allude is enlargement of the thyroid gland.

"The first case of this coincidence which I witnessed was that of Grace B., a married woman, aged thirty-seven, in the month of August, 1786. Six years before this period she caught cold in lying-in and for a month suffered under a very acute rheumatic fever; subsequently to which, she became subject to more or less palpitation of the heart, very much augmented by bodily exercise, and gradually increasing in force and frequency until my attendance, when it was so vehement that each systole of the heart shook the whole thorax. Her pulse was 156 in a minute, very full and hard, alike in both wrists, irregular as to strength, and intermitting at least once in six beats. She had no cough, tendency to fainting, or blueness of the skin, but had twice or thrice been seized in the night with a sense of constriction and difficulty of breathing, which was attended with the spitting of a small quantity of blood. She described her-

self also as having frequent and violent stitches of pain about the lower part of the sternum.

"About three months after lying-in, while she was suckling her child, a lump about the size of a walnut was perceived on the right side of her neck. This continued to enlarge from the period of my attendance, when it occupied both sides of her neck, so as to have reached an enormous size, projecting forward before the margin of the lower jaw. The part swelled was the thyroid gland. The carotid arteries on each side were greatly distended; the eyes were protruded from their sockets, and the countenance exhibited an appearance of agitation and distress, especially on any muscular exertion, which I have rarely seen equalled. She suffered no pain in her head but was frequently affected with giddiness.

"For three weeks she had experienced a considerable degree of loss of appetite and thirst, and for a week an edematous swelling of her legs and thighs, attended with very deficient urine, which was high-coloured and deposited a sediment. Until the commencement of the anasarcaous swelling she had long suffered night sweats which totally disappeared as the swelling occurred. She was frequently sick in the

morning and often threw up fluid tinged with bile."

At the present time when laboratory procedures of all types figure so largely in clinical diagnosis, it seems appropriate to recall the limited facilities for investigation which were available to physicians of earlier generations. Despite this fact, most of the clinical entities known today were recognized by these men through careful consideration of the history and keen utilization of the senses of sight, hearing and touch. The inestimable value of laboratory investigation in the recognition of disease is not to be denied, but dwarfing of acumen which may result from too great reliance on these data should be avoided.

The absolute necessity of accurate diagnosis as a prerequisite to intelligent treatment is recognized by all engaged in the practice of medicine. If one quality of the examining physician was to be emphasized, which probably is more responsible for accurate recognition of disease than any other single factor which he might possess, it would be *thoroughness*. Without thoroughness in his examination even the most astute clinician or surgeon will fail in certain cases to detect perhaps the one symptom or clinical finding which might lead to the true diagnosis. Thoroughness requires time which even the busiest and

most hurried physician must be willing to spend if error is to be avoided. Accurate diagnosis includes not only the recognition of full-blown disease, when it is presented as such, but also the detection of any pathologic process in its earliest stage when treatment can be administered most effectively. Unfortunately, the descriptions of many diseases in numerous textbooks emphasize too greatly abnormalities which are present only late in the progress of the disease. To offer the best opportunity for early and permanent cure disease must be recognized at its onset, in its early stages, before complications and distant effects make its presence obvious to the most inexperienced. Little good is afforded the patient by recognition of a primary malignant growth through secondary metastatic developments. Great emphasis should be accorded early symptoms in teaching the undergraduate medical student. He will become all too familiar with the findings of far advanced disease following his graduation.

On behalf of the Editorial Board of the American Journal of Surgery I wish to express our appreciation to all the authors who contributed the excellent and instructive articles presented in this issue of the Journal.

JAMES T. PRIESTLEY, M.D.



# War Surgery and Traumatic Lesions

## EARLY DIAGNOSIS OF CRANIOCEREBRAL INJURIES\*

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IT is, or should be, axiomatic that diagnosis is no more than a word picture of the pathological condition produced by disease or injury. In injuries this condition is organic. Moreover, it is indisputable that objective signs will be of greater diagnostic import than subjective symptoms and that the less such signs are subject to individual variations of interpretation by the physician and patient the greater is their diagnostic accuracy. Such sweeping generalities must be qualified by the proviso that the indicated pathological changes are known and not merely inferred and that it is possible to demonstrate reliable objective variations from the normal. In this particular problem, it is also true that when attempts are made to use subjective symptoms or objective signs whose significance depends on alternative interpretations by the physician, great care must be exerted to avoid ascribing diagnostic significance to what are actually lateralizing or prognostic data.

An appreciation of the above diagnostic fundamentals is of more than usual importance in dealing with head injuries. Physicians and surgeons who have been trained in the more leisurely schools of neurology and tumor neurosurgery are frequently at a loss in the hurly-burly of craniocerebral injuries in which decisions have to be made rapidly and without benefit of the detailed meticulous study that tradition has decreed must precede the diagnosis of intracranial disease. Moreover, the clouding of the picture by associated injuries, rapid intra-

cerebral changes that may not only vitiate otherwise reliable signs but actually apparently reverse their significance, and complications such as surgical shock and dehydration lead to profound diagnostic errors, ill-conceived therapy and higher mortality. There is a great need for sanity and objectivity in the diagnosing of the intracranial pathological conditions that result from acute craniocerebral injury.

*General Considerations.* Before anything further can be done in the diagnosis of a craniocerebral injury, the surgeon must first satisfy himself that not only has the patient sustained a blow on his head but also that the blow has been of sufficient magnitude to produce intracranial pathological conditions. I do not mean to underestimate the importance or significance of lacerated wounds, contusions or hematomas of the scalp. They are neglected here only because of lack of space. On the other hand, I am sure that a fracture of the vault or base of the cranium can never occur in the absence of some degree of brain injury if the latter is properly and promptly looked for.

The fact of the patient's having sustained a blow on the head will be demonstrable by the presence of a bruise, cut or hematoma of the scalp, by the observation of reliable witnesses or by the demonstration of a fracture of the skull. Except in what may be classed as perforated wounds of the skull, the significance of the blow in terms of brain injury will depend upon the demonstration of loss of consciousness or a

\* From the Department of Neurosurgery of the Boston City Hospital.



period of amnesia covering all or part of the time of the accident and extending a variable distance antecedent to and after the injury. Such amnesia results from and predicates unconsciousness.

Consciousness is a relative term that has to do with one's awareness of his surroundings. No person can be completely conscious at any given instant. Loss of consciousness predicates a decrease in one's awareness of one's surroundings. At one extreme the patient is completely out of touch. On recovery of consciousness he will be forever unable to fill in this void in his existence and will only then recognize it as having been a void. On the other extreme, the patient will be so little out of touch that until checked by the observations of impartial witnesses he will be unaware that any void has existed. Neither condition requires immobilization or necessarily unusual or abnormal activity on the part of the patient, although neither obviates such conditions. Demonstration of the first will be all too apparent when the patient is asked to do something unusual while unconscious, or on recovery of consciousness, has an apparent amnesia. The classical and common example of this is found in the football player who, after being kicked on the head at the start of the fourth quarter and after being removed ten minutes later because of a failure to hold onto a forward pass that was thrown into his arms, was unable to find his way to the locker room and still later inquired as to what team he had been playing against and what the score was at the end of the third quarter. Demonstration of the second may be extremely difficult and may involve the interviewing of others beside the patient. From these witnesses data must be obtained relative to associated facts and incidents that might have or did happen at the time of the accident. Later cross-questioning of the patient in regard to these specific proved instances must then be carried out in an endeavor to demonstrate decrease in his awareness of these surroundings. Many such patients will admit to

having been "dazed," "woozy," "groggy," "dizzy," or other similar conditions while at the same time they will vehemently deny having been "unconscious." It should be noted that regardless of the degree of unconsciousness, the time factor is of little diagnostic significance. I am convinced that unconsciousness as such has no more diagnostic significance than that its presence demonstrates that a blow severe enough to produce some degree of brain injury has struck the victim's head. On the other hand, its true absence—not an absence that depends for its proof on such data as the unsupported opinion of the victim or his failure to develop physical immobility—indicates an absence of brain injury except in perforated wounds of the skull and brain. This, as has been pointed out by Denny-Brown and Russell,<sup>1</sup> is dependent upon the relative mass of the striking object and the head, as well as the velocity of the striking object. The smaller the mass, the more local is the effect and hence the less the likelihood of the production of unconsciousness. Changes in consciousness occurring later and in the course of treatment are prognostic and not diagnostic. For practical purposes, I believe that one may consider a patient who has either an obvious scalp injury, fracture of the vault or base of the skull or a reliable history of a blow on the head as having been struck on the head. If, in addition, one can demonstrate any degree of loss of consciousness, regardless of its length or severity, and especially if it is or has been associated with amnesia, the surgeon must conclude that the blow has been severe enough to produce some degree of brain or intracranial pathological condition.

#### NONOPERABLE GROUP OF ACUTE CRANIOCEREBRAL INJURIES

Those acute cerebral injuries the pathology of which is such as not to call for operative therapy are concussion, edema and congestion, contusion and/or laceration and perforating wounds of the skull. The analogous cranial conditions are those

in which the condition consists of a linear or diastatic or comminuted fracture of the skull that is *not* compounded and that neither enters an air sinus nor the nose and that has not torn into any of the large venous sinuses, the middle meningeal or the internal carotid artery. These latter will always be accompanied by some degree of brain injury and the diagnosis should always include a description of this important part of the craniocerebral pathological condition.

#### *Acute Nonoperable Cranial Injuries.*

The diagnosis of the acute nonoperable cranial injuries is not difficult. Simple linear or diastatic or comminuted fractures of the vault are only diagnosable by x-ray examination. To be accurate and significant the films must include right and left lateral stereoscopic views. Single films are not conclusive except in certain special instances. Since the demonstration of such fractures has no therapeutic significance, x-rays taken for the purpose should always be postponed until after the patient has recovered consciousness and is again co-operative. Fractures into the nose by way of the cribriform plate are usually not diagnosable by x-ray. Their presence is recognized by the leakage of cerebrospinal fluid from the nose or into the posterior nasopharynx. Such a diagnosis calls for therapy at the earliest possible moment if the patient is to be saved from meningitis. The presence of a fracture into any of the air sinuses should be suspected whenever there is prolonged bleeding from the nose just as fractures into the ear should be suspected when there is excessive bleeding from the latter. Of course, local damage to both nose and ear must first be eliminated as the cause of the hemorrhage. Battle's sign—a subcutaneous hematoma that develops in the region of the mastoid an appreciable time after the receipt of the injury—is probably pathognomonic of a fracture extending into the mastoid. Adequate x-ray studies will demonstrate most of the fractures into the air sinuses and many but not all of the fractures into the

petrous ridge. The presence of a suspected fracture of the posterior wall of the frontal sinus must be verified as soon as possible because if there is reason to suspect that the mucous membrane of the sinus has been torn in addition to or because of the fracture, the latter must be considered to have been compounded into the nose with all that that implies in the line of treatment. This is one of two conditions in which diagnostic x-ray studies are imperative at the earliest possible moment. The other is whenever the surgeon has reason to suspect the presence of an extradural hemorrhage. In both instances, because the diagnosis may have to be made before the patient is co-operative the surgeon will usually have to be content with a single film. To have this film satisfactory and of diagnostic significance, he must be prepared to tell the roentgenologist the area of the skull that he wants to study, must be willing to assume the responsibility for moving the patient to an x-ray room and must co-operate with the roentgenologist in holding recalcitrant patient's heads quiet by force if necessary during the exposure. In return for that the surgeon can expect from the roentgenologist a film that will show not only the fracture line but also the shadows of the grooves of the middle meningeal artery, the superior sagittal and the lateral sinuses, and the posterior wall of the suspected frontal sinus. Fractures that involve the cavernous sinus and the internal carotid artery are diagnosable only by inference, being usually invisible by x-ray. Their presence can be inferred whenever a unilateral orbital bruit or pulsating exophthalmos develops a short time after a head injury. In the absence of such an arteriovenous fistula, the fracture is undiagnosable except by chance.

#### *Acute Nonoperable Cerebral Injuries.*

In discussing the diagnosis of acute nonoperable cerebral injuries, it is worth while to consider in some detail the pathological condition spoken of clinically as concussion. This is the least severe result of a blow on the head. It is always present, however,

in association with more severe and more lethal generalized traumatic cerebral conditions. The pathology of concussion is not known in all details. Denny-Brown and Russell<sup>1</sup> have presented experimental evidence to show that in animals the phenomenon of concussion which they define as "direct traumatic paralysis of nervous function without vascular paralysis" can only be produced "by subjecting an animal's head to a sufficiently high rate of change of velocity or by a crushing injury such as striking the head while it is supported on a hard surface." The first they call "acceleration concussion" and the second "compression concussion." They claim that the paralysis of concussion is immediate and antedates any vascular changes that take place even as the result of vascular stress, except for "an increased blood flow through the brain and brain stem." In addition, they found that the vagoglossopharyngeal system is often stimulated by subthreshold blows with resultant depression of cardiac, vasomotor and respiratory function for short periods. Also that when failure of blood pressure results from severe head injury, the mechanism appears to be identical with that of primary surgical shock—"and is associated with peripheral vaso-constriction and paralysis of the venous side of the circulation." Clinically, my experience leads me to believe<sup>2</sup> that in man alteration in the cerebral arteriolar and capillary circulation is perhaps coincidental with the later phases of such concussion and, in any event, may follow after so closely as to be undistinguishable as part of the phenomenon. To be sure, these conclusions are inferential rather than evidential but even so have the merit of having served as a satisfactory basis for the therapy applied to the craniocerebral injuries seen during the past ten or more years. These latter changes are apparently initiated by the vasovagal reflex and, in any event, are associated with unconsciousness.

With their return to normal, consciousness also returns and there is no longer

either subjective or objective evidence of any cerebral pathological condition, that is, the patients have neither signs nor symptoms of an injury. Because, as far as is known, no patient has ever died while suffering from clinical concussion alone, the condition cannot be more certainly identified. Also, inasmuch as the period of unconsciousness is always short, often being a matter of seconds, direct observations in men have not been made during that time in regard to intracranial pressure, the chemistry of the cerebrospinal fluid, and so forth. Furthermore, other than the associated unconsciousness, the vascular changes if present produce no signs or symptoms. The diagnosis, therefore, depends first upon the demonstration of a blow on the patient's head which produced unconsciousness and second upon the further demonstration that on recovering consciousness the patient complained of no symptoms and on extended examination had no signs of any injury, with the occasional exception of damage to the scalp or fracture of the skull. In other words, as far as the patient knows on recovery of consciousness, he is well and normal. The diagnosis of clinical concussion uncomplicated by anything except a scalp injury or simple fracture of the skull can be made only under such conditions. If and when made, it is obvious that being well, the patient requires no treatment, no hospitalization and no convalescent care and cannot have, by any stretch of the imagination, a "postconcussion state" that has any connection whatsoever with his head injury.

When the injury to the patient's head is more severe, however, further pathological changes take place in the brain and further diagnoses must be added to that of concussion. These are, in order of severity, edema and congestion, contusion and laceration of the brain. Each succeeding one is added to all the preceding less severe conditions. All varieties of subjective symptoms occur in any combination in all of these conditions. In general, however, it may be said

that to the unconsciousness of concussion is added the headache and dizziness of edema, the disorientation, confusion or stupor of contusion and the coma of laceration. Because the brain is affected as a whole even although the maximum damage may be limited to one area all conceivable combinations of reflex, sensory and cranial nerve abnormalities may be found in any given case. Such wide variations as hemiplegia and Jacksonian convulsions in children with cerebral edema, and supernormal activity without somatic reflex changes in adults with lacerated brains are frequently seen. I have even seen such physical changes as are usually considered to indicate decerebration clear up after nonoperative therapy and the patient leave the hospital in essentially normal condition. To be sure, such classical signs as the Babinski, increased reflexes in a paralyzed limb or combined facial and acoustic nerve paralysis occurring on the same side have certain localizing values but cannot be considered diagnostic of the pathological cerebral condition that underlies them. Edema of the optic nerve heads points only to increased intracranial pressure. Fixed dilatation of one pupil occurs not only in nonoperable but more usually in operable conditions and although considered by some to be of lateralizing significance has not proved to be so in my experience. Bilateral fixed dilated pupils is a prognostic rather than diagnostic sign and is commonly seen just before death. Increasing coma or a trend toward coma from confusion or disorientation is only prognostic and indicates unfavorable progress and the need for more and increasingly accurate diagnostic studies.

How then can one diagnose these conditions? The answer to this question is found in a knowledge of the changes in normal cerebral physiology that the pathological condition there present has produced. Just as unconsciousness following a head injury is the diagnostic touchstone for concussion, so too edema and congestion, and contusion and/or laceration have their own peculiar

and recognizable additional objective signs. When edema and congestion are present there is, among other things, an increase in the brain volume, a rise in intracranial venous pressure and often petechial and coalescing intracortical hemorrhages. The cerebrospinal fluid pressure is forced up until such time as the intracortical condition returns to normal, but the cerebrospinal fluid itself remains unchanged both as to cell content and chemistry. Thus, the condition can be diagnosed by demonstrating an increased intracranial pressure and normal cerebrospinal fluid in a patient who has been knocked unconscious by a blow on the head. This is easily done by a lumbar puncture during which the pressure is measured by an appropriate manometer and sufficient cerebrospinal fluid collected for chemical and cytological studies. Other things being equal, this is the only way, in my experience, in which this diagnosis can be made from indisputable facts. Of course, the findings will be normal if this examination is carried out after the edema and congestion have subsided.

Contusion and/or laceration, as pointed out above, are associated with and are present in addition to clinical concussion and edema and congestion. In my experience they cannot and do not occur separately, although Denny-Brown<sup>3</sup> and Eden and Turner<sup>4</sup> claim that contusion does so. I believe that apparent absence of concussion and edema can be accounted for, except in perforating wounds, by the willingness of the surgeon to accept the patient's unverified word as to unconsciousness and to the absence of factual data as to the presence of complicating dehydration. The diagnostic criteria then must include unconsciousness following a blow on the head and the demonstration of an increased intracranial pressure. The cerebrospinal fluid, however, will differ and will no longer be normal as to either cytology or chemistry. By definition, both contusion and laceration imply a rupture of surface vessels with escape of red blood cells into the cerebral subarachnoid spaces.

Since absorption of cerebrospinal fluid takes place from these spaces into the venous sinuses by way of microscopic openings in the walls of the arachnoidal villi or Pacchionian bodies; and since these openings are too small to allow the passage of red-blood cells, they shortly become plugged to a varying degree by the free cells that have been loosed in the cerebrospinal fluid as the result of the contusion or laceration. This causes a backing up of the cerebrospinal fluid in the ventricular and subarachnoid reservoirs with a consequent further rise in intracranial pressure. In addition, examination of the cerebrospinal fluid will demonstrate an abnormal cell count, a change in color and an increase in total protein content. These changes will vary with the amount of free bleeding that has taken place into the cerebrospinal fluid. The color will range from the light pink fluid of the acute mild contusion to fluid that resembles pure blood and that is found in the fresh severe laceration. The decision as to whether a borderline case is contusion rather than laceration will vary with the individual surgeon's interpretation. Thus, contusion and/or laceration of the brain can be diagnosed and, in my opinion, only diagnosed, other things being equal, by demonstrating that the patient has been knocked unconscious by a blow on the head, has a higher than normal intracranial pressure and has a bloody cerebrospinal fluid.

*Perforating Wounds of the Skull.* Perforating wounds of the skull either with or without injury to the meninges and brain beneath the perforation are extremely rare in civilian practice. At the last analysis, they are compound fractures but because of their size, their frequent multiplicity and the nature of the perforating agent they can, in most instances, be considered to be uncontaminated and therefore in no need of débridement. Attention has recently been called to their importance in war by Eden and Turner<sup>4</sup> who speak of the cerebral injury as "focal contusion." They point out that such a contusion is not

preceded by or even necessarily accompanied by any loss of consciousness. They and Denny-Brown and Russell<sup>1</sup> state that the explanation of the phenomenon is found in the fact that the brain as a whole is not affected by such wounds because the missile is small and because its velocity is such that the energy inherent in it is largely dispersed in its passage through the skull and yet is not enough to fragment the adjacent bone or force particles of scalp or head covering into the cranial cavity. As the size and velocity or energy of the missile increases the depth of penetration as well as the extent of the damage and hence the liability to symptoms attributable to involvement of the entire brain, increases also. Glass and small metallic fragments are said to be the common causes of such war wounds. Denny-Brown<sup>3</sup> and Denny-Brown and Russell<sup>1</sup> describe another type of local contusion without associated concussion as being caused by the "piston effect" produced by slightly larger missiles. These cause a sudden sharp rise and fall of intracranial pressure and more extensive but still localized cerebral damage. These diagnoses are made from the history, the demonstration of evidence of local cerebral contusion or laceration without associated generalized brain damage and the visualization of the metallic fragments by x-ray.

My experience has been limited to four instances of perforating wounds of the skull. One was caused by fragments of glass from an automobile windshield. Their presence was unrecognized for nine months after the accident and then only because they were found in the course of draining what until then had been thought to be a cortical abscess of unknown etiology. Two were stab wounds, in one of which a kitchen knife entered the cranial cavity by way of one orbit. In the other a pocket-knife blade had been driven through a child's parietal bone. In the last case another child had fallen head first onto the sharp end of a long upholstery nail. The nail had penetrated the skull and underlying meninges and

brain. Unconsciousness was present in the first case only. The diagnosis in the last three cases was not difficult because all the patients arrived in the hospital with the perforating implement still in place in the various wounds.

Bullet wounds must be considered as compound fractures and not as perforating wounds because, with only rare exceptions, their effect on the brain is widespread and in no way analogous to a "local contusion."

#### OPERABLE GROUP OF ACUTE CRANIOCEREBRAL INJURIES

The operable group of usual acute craniocerebral injuries includes depressed fractures of the skull, compound fractures (including bullet wounds) of the skull, extradural and subdural hematomas. It should be clearly understood and cannot be repeated too often that there is *always* some form of nonoperable acute cerebral pathological condition accompanying all of these operable injuries. Rarely it may be so fleeting as to be undiagnosable by the time the patient reaches the surgeon but no dependence can be placed on this fortunate occurrence and these diagnoses, when correctly made, must include a word picture of the associated nonoperable brain injury. This portion of the diagnosis is made in the same way and based on the same criteria that are described above under nonoperable cerebral injuries.

*Acute Operable Cranial Injuries.* Insofar as the skull injury is concerned, the diagnosis of the acute operable cranial injuries presents no great difficulty provided that the need for diagnosing the associated cerebral injury is kept always in mind. The simplest form is the depressed fracture. This diagnosis can be made only by x-ray examination and then only with the aid of stereoscopic lateral views and possibly some especially angled views. Attempts to make this diagnosis without x-ray films and by palpation have a 50 per cent chance of error because of the palpable similarity between these fractures and subperiosteal hematomas.

Compound fractures of the skull, except as mentioned above, occur only in the presence of a wound of the scalp and only then if all the layers of soft tissue, including the pericranium above the fracture line, are torn and the fracture brought into actual or potential contact with the outside world. An accurate diagnosis can be made only by palpation with the finger, after it has been rendered sterile, of the fracture line through the scalp wound. If the scalp wound is too small to permit this, it should be deliberately enlarged. If it has been sutured and the surgeon is unwilling to allow the responsibility for the diagnosis to rest on the man who sewed it up, the sutures should be removed and the wound examined after that. There is no substitute for the surgeon's sterile finger in making this diagnosis. Neither probes, lights, x-ray films nor any other method compares with the finger in efficiency or accuracy. The best way to sterilize one's finger is to put a dry sterile glove on over the unwashed hand taking care, however, not to contaminate its fingers or palm in doing so. Bullet wounds should be x-rayed not so much for the purpose of diagnosis as to locate the foreign body prior to attempts at treatment. These two operable cranial injuries always have associated with them some type of nonoperable cerebral injury. They may also occur either alone or together or in combination with extra- or subdural hematomas or both.

*Acute Operable Cerebral Injuries.* The most difficult condition to diagnose of all those connected with acute craniocerebral injuries is the extradural hemorrhage. Maltby and I<sup>5</sup> have recently considered this and other aspects of the problem in detail and I will deal only with certain of the more important features here. At best, the diagnosis can only be tentative until confirmed by exploratory operation or autopsy. In spite of a small percentage of error, the surgeon is obligated to make this diagnosis and institute immediate operative therapy whenever he elicits a pathognomonic history. This will be whenever

he can get a history of unconsciousness following a blow on the head followed by a period of consciousness, which in its turn is followed by another and slowly developing second period of unconsciousness. The diagnosis can be strengthened by an x-ray examination as described above, and by demonstration of a high intracranial pressure with normal cerebrospinal fluid. The clot can be lateralized by the demonstration of contralateral hyperreflexia with or without hemiplegia, Jacksonian convulsions, aphasia, asternognosis, hemianesthesia and the like. However, of all of these signs the most informative is the x-ray film. Large clots that develop slowly will produce ipsilateral hemiplegia and reflex changes; clots that are formed as the result of leakage from the anterior or posterior branch of the middle meningeal artery or the lateral sinus or its tributary veins need not cause any signs of motor deficit, or any other specific signs if they happen to be cerebellar; surgical shock or dehydration will keep the intracranial pressure from rising, and an associated contusion or laceration of the brain will change clear to bloody cerebrospinal fluid. The unreliability of these so-called classical diagnostic signs can be better appreciated when it is realized that the first attack of unconsciousness is caused by the associated brain injury. The conscious interval is present only when the patient has recovered from the brain injury and is not yet rendered unconscious by the growing extradural clot. The final unconsciousness arises from pressure exerted on the brain by the growing clot. It is apparent, therefore, that the conscious interval, which is what makes the history pathognomonic, depends for its presence and length on the severity of the brain injury and the rapidity with which the clot grows to a lethal size. It can be, therefore, and in large numbers of instances is, fleeting or absent, thus making the history no different from that of a severely lacerated brain. Finally, a slow pulse and a rise in blood and pulse pressures are not signs of an extradural hemorrhage any more than changes

in the eye grounds are. They, like the latter, are evidences of severe and rapidly rising increased intracranial pressure. Because they usually do not develop until compression and early edema of the medulla is present and because by that time most patients who have an extradural hemorrhage are moribund, they are not often seen in connection with this lesion. Tradition and text book statements would give one to understand that this combination is common and is almost as pathognomonic of extradural hemorrhage as the history. However, this, like the belief held by many surgeons that extradural hemorrhages are exclusively arterial and never venous, evidence lack of experience rather than accuracy of observation.

Extradural hemorrhage should be suspected as a diagnosis whenever its pathognomonic history has been obtained. Patients who do not give a history of the first period of unconsciousness after a blow on the head and are first seen by the surgeon while conscious are only slightly less liable to be suffering from this lesion than those with the pathognomonic history. This will be doubly true if unconsciousness develops later and thus forms two-thirds of the pathognomonic triad. The diagnosis will be confirmed to the extent of necessitating immediate operation without the need of further evidence if a fracture line can be shown by x-ray to cross any part of the middle meningeal artery, the superior sagittal or the lateral sinuses. In case of doubt or in case a patient on whom a diagnosis of nonoperable cerebral injury has been made, gets worse or fails to improve in spite of efficient nonoperative therapy, unilateral and, if necessary, bilateral exploratory transtemporal trephinations should be promptly resorted to as a final diagnostic procedure.

Many half truths have been written and innumerable conclusions based on inadequate evidence have been published relative to the diagnosis and symptomatology of subdural hematomas. The profession at large persists in thinking of these clots as a

chronic disease and fails to recognize that every chronic condition is acute at some time and even worse—fails to act on the well recognized doctrine that proper therapy during the acute stages will do away with the chronic feature. For simplification and to eliminate as much as possible the element of personal interpretation on the part of the surgeon, I have classed subdural hematomas as acute when they are diagnosed during the time that the brain injury is still recognizable in terms of pathology, and as chronic when the brain injury is a thing of the past, healed and present only as the final end point of the acute process. I propose to deal only with the diagnosis of the acute subdural hematomas at this time. I have covered other aspects of this problem in a study of 310 such clots which is published elsewhere.<sup>6</sup>

Before dealing with the diagnosis, it should again be emphasized that all subdural hematomas when they are first formed, consist of blood and cerebrospinal fluid mixed in varying proportions and incarcerated in the cerebral or cerebellar subdural space. If the blood is at a maximum and the cerebrospinal fluid at a minimum or absent, a solid clot will be formed. This will be organized by the dura from the surfaces toward the center and if not removed, will eventually become either a fibrous thickening on the dura or a collection of encysted fluid. While such clots are forming and before organization begins they act as expanding lesions and raise the intracranial pressure. If the clot is large and organizes slowly, this pressure may stay elevated for a number of months. If the clot organizes quickly and the brain adjusts its volume easily to this new cranial content, the intracranial pressure may return to normal in a few days. This is the least common form of subdural hematoma and is the one written about as "chronic subdural hematoma." It is the type that is produced by birth injuries and any trauma that ruptures a bridging vein without associated brain injury, or a pial vein with minimal brain injury. The history is one of

a trivial head injury accompanied either by fleeting unconsciousness or none at all. There is frequently an interval in which no symptoms are present—the so-called latent period—to be followed when the clot grows big enough, by indefinite subjective complaints such as headache, lack of interest and initiative, impaired judgment and the like or by the usual signs and symptoms of increased intracranial pressure such as are seen with cerebral tumors. The diagnosis can and should be suspected when persistent subjective symptoms or persistently increased intracranial pressure follow an insignificant brain injury and particularly when that injury has been properly diagnosed and adequately treated. The diagnosis will be rendered probable by demonstrating, by means of ventriculography, a space-occupying lesion on the surface of the cerebrum and will be confirmed by the finding of the clot at either an exploratory transtemporal trephination or beneath a flap craniotomy.

The commonest type of subdural hematoma, whether acute or chronic, is the one that is always associated at the start with a contused or lacerated brain. This hematoma is formed from a mixture of blood and cerebrospinal fluid which is incarcerated within the cerebral subdural space. The blood comes from ruptured pial veins and the cerebrospinal fluid from the subarachnoid space. Both reach the subdural space by way of a tear in the arachnoid. Since this tear closes in a few hours, the mixture is henceforth irremovable except by mechanical drainage. Because of the osmotic relationship between this subdural mixture on one side and the normal cerebrospinal fluid on the other side of the arachnoid, which acts as a dialyzing membrane, the hematoma is an expanding lesion for times varying from five weeks to ten days, depending on the amount of blood that has been originally mixed with the cerebrospinal fluid in the subdural space. Thus, because this type of subdural hematoma will always be found in association with either a contused or lacerated



brain, the ordinary signs and symptoms that are present by virtue of the brain injury will have no other or special diagnostic significance in relation to the subdural hematoma. The increased intracranial pressure that is produced by the hematoma will be present anyhow as a result of the brain injury as will changes in the cerebrospinal fluid. They also will not have any special diagnostic significance in relation to the hematoma. The history will be that of a head injury that produced unconsciousness. In a word, it is impossible, except by a good guess, to make a differential diagnosis of the common type of acute cerebral or cerebellar subdural hematoma from the commoner forms of nonoperable brain injuries by the usually available signs and symptoms. Other and more complicated diagnostic procedures must be used. Only the intracranial use of air and the exploratory operation are left. Although advocated by certain authors,<sup>7,8</sup> I do not approve of the use of air in the face of acute cerebral injury and, therefore, have had no experience with it. On the other hand, a considerable experience with diagnostic subtemporal trephinations has satisfied me that if properly done in a properly staffed and equipped hospital, they do not materially add to the patient's risk if negative, and often save his life if positive. They not only establish the diagnosis but institute much needed therapy. Inasmuch as all these patients will or should have a diagnosis of contusion or laceration of the brain made on them promptly and since with the establishment of that diagnosis efficient nonoperable therapy will have been instituted at once, failure on the part of the patient to improve or the fact that he is getting worse in spite of adequate therapy should suggest to the surgeon that his diagnosis is wrong or incomplete and should make it mandatory for him to proceed to further investigation. It is at this point that the exploratory trephination is indicated—not because a diagnosis of subdural hematoma has been made but because the only diagnosis justified by the

evidence collectible to date has not led to proper therapy, and because an unrecognized subdural hematoma is a strong possibility as a cause of this failure. I am convinced that no one can diagnose an acute subdural hematoma prior to exploratory trephination except as a guess.

Intracortical hematomas are not common as the result of a blow on the head. They cause no characteristic signs or symptoms which will serve to differentiate them from the more serious types of nonoperable cerebral pathology. They have no typical history and just as with the acute subdural hematomas cannot be diagnosed by any means short of exploratory trephination except by guesswork.

#### COMPLICATIONS

Of the complications that develop in association with acute craniocerebral injuries, the most important are surgical shock and toxic dehydration. Others that are less important are meningitis, aerocele and arteriovenous aneurysm.

*Surgical Shock.* The diagnosis of surgical shock need not be gone into in detail here. Suffice it to say that from a practical point of view any patient who has a pulse pressure below 20 mm. of mercury can be considered to be in surgical shock and should be dealt with accordingly. On the other hand, any patient whose pulse pressure is over 20 mm. of mercury can be considered as not being in shock. Those whose pulse pressure is exactly 20 mm. must be regarded as borderline cases whose final classification must await further observations. Surgical shock will produce of itself an intracranial pressure that is well below the expected minimal level for the associated cerebral injury.

*Dehydration.* Dehydration as a cause of symptoms and as a significant complication of acute craniocerebral injuries is usually regarded as a myth. Criteria that demand exact diagnoses based upon demonstrable undisputable facts rather than diagnosis by inference will, however, if the surgeon's

experience amounts to anything, shortly demonstrate that this comfortable theory has no basis in fact. Unconscious patients who, after injury, have been exposed to the sun following their accident; who have not been given sufficient fluids because of their inability to ask for them, or because of arbitrary limitation of fluid intake, or who have been vomiting; or who, in spite of having a high temperature have been surrounded by artificial heat in the shock-room of the hospital; or have been treated with artificial dehydration injudiciously and, as far as the condition goes, ignorantly, are all potential sufferers from toxic as opposed to therapeutic dehydration. The diagnosis should be suspected in the face of such a history—particularly if the patient's skin is dry, if he has developed a fever, or has been having, if an adult, less than 5,000 cc. of fluid every twenty-four hours regardless of the other methods of treatment. The diagnosis is probable if, in addition to any of the above, the patient who has previously been getting better suddenly begins to get worse and again develops signs and symptoms that he had had previously but that had disappeared under treatment. The diagnosis is certain if it can be demonstrated that in addition to the above his intracranial pressure is below the expected minimal level that is appropriate to the cerebral pathology that is present. In severe cases and in children it can be further confirmed by the demonstration of acetone or diacetic acid in the urine or an abnormality of the carbon-dioxide combining power of the blood, in which cases it leaves the group of toxic dehydration and becomes acidosis.

*Meningitis and so forth.* The diagnosis of meningitis is made from the classical signs and presents no problem other than that associated with identification of the infecting organism and the route by which that organism has reached the meningeal spaces. This has been dealt with sufficiently above, as has the diagnosis of an arteriovenous fistula. Aeroceles are diagnosed by x-ray.

## CONCLUSIONS

A diagnosis should be a word picture of the pathological condition that is present and that leads to the need for making a diagnosis. Its accuracy will vary directly with the objectivity of the signs and symptoms upon which it is based, and their freedom from the possibility of individual variations of interpretation by the surgeon and the patient. This holds particularly true in the diagnosis of acute craniocerebral injuries.

A prerequisite to the diagnosis of any acute craniocerebral injury, except perforating wounds of the skull, is the demonstration of the fact that there has actually been an injury to the patient's head and that he has been knocked unconscious as the direct result of that injury.

Accurate diagnoses of uncomplicated nonoperable craniocerebral injuries are dependent first upon the history as noted above, then on a study of the make-up and pressure of the cerebrospinal fluid. Diagnoses made without these data are inferential rather than factual and can be successfully disputed before impartial judges.

Accurate diagnoses of uncomplicated operable craniocerebral injuries will always include a word picture of the associated nonoperable cerebral condition. In addition, certain data that are obtainable only by special x-ray examination, palpation through a scalp wound, a detailed history of the development of symptoms after the accident, and the use of an exploratory trephination whenever the patient's progress does not coincide with the diagnosis already made are necessary.

More attention should be paid to the possibility of significant complications of acute craniocerebral injuries. This is particularly true in regard to surgical shock, toxic dehydration and acidosis.

Accurate diagnoses of common complications of acute craniocerebral injuries will depend upon a knowledge of the cerebral pathological condition that has been produced by the head injury, a study of the pulse pressure, a study of the patient's

history in relation to exposure to heat, fluid intake and limitation, the administration of dehydrants and the level of the intracranial pressure.

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THIS (neuralgia) is a painful symptom attributed to a nerve or its branches. The pain has a "pricking" quality, often of exquisite intensity, intermittent in duration (free intervals), and may have a wide distribution or radiation. It is an expression of a lesion involving nerve roots, nerve trunks, or their ganglia.

# STAB WOUNDS OF CHEST WALL AND LUNGS

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THE concentration of thousands of men at various places in the country and particularly in the South, is likely to increase the incidence of stab wounds seen by both military and civilian physicians. A review of the subject is timely.

No class of wounds, unless it be in a few centers of the brain, involves the essential physiologic processes of the body more rapidly than wounds of the chest. In addition to the rapid physiological changes which must be met, many pathologic sequellae may be expected. No class of wounds requires more accurate judgment at onset or more persistent care during its course.

Injuries and wounds of the chest have been classified in several ways. Lilienthal<sup>1</sup> divides them into superficial, penetrating and perforating, the last two classes being differentiated only by degree. A simpler classification is given by Cole<sup>2</sup> into external and internal chest injuries, while Bigger<sup>3</sup> calls them perforating and nonperforating. A similarly explicit description may be made of superficial wounds which involve layers of the thoracic wall to the parietal pleura, and deep wounds which extend through the parietal pleura to varying depths.

An analysis of the type of wound upon which this paper is based may be estimated from the figures for the thoracic service in a two hundred sixty bed city and county hospital for one year and will serve as an average cross section of these injuries. The wounds are similar to those discussed by Elkin.<sup>4</sup> Two hundred ninety-seven patients with chest wounds were received in the emergency room. General figures showed eighty-eight to be white and two hundred nine to be colored; two hundred

four were males and seventy-one females; twenty-two were dead on arrival. The causative agents of the chest wounds were; nineteen from automobile accidents, eighteen from gunshot wounds, seven from industrial injuries or minor accidents about the home or farm. The remainder of the two hundred fifty-three wounds were hand inflicted apparently with homicidal intent. It is with this last group that we are interested. Of these chest injuries, ninety-four were committed with knives, fifty-seven with ice picks, twenty-one with razors, one with a hatchet and in fifty-eight cases the patient either did not know or was unwilling to tell what weapon was used. These figures are summarized in Figure 1. Fortunately for the hospital, the majority of the chest wounds are superficial in type, and of two hundred fifty-three stab wound cases, only one hundred four were admitted to the wards.

Among the negroes, (the two to one offenders) the ice pick is a favorite weapon; it costs five cents, is not conspicuous, looks bad when drawn and with a metal handle may easily be thrown a hundred or more feet when it is time for flight. The "switch" or spring released knife, the blade of which varies from four to six inches, is a more expensive favorite. A "frog" is a single bladed knife, three and one-half to five inches, whose pin is oiled and spring filed so that it can often be opened "on the throw" almost as rapidly as a switch. With such social accoutrement, negro night life adds to emergency room excitement.

Peculiarly, very few bayonet wounds of the chest were seen in the hospitals during the last war. The reasons given for this are: first, that the wounds were so severe that the victim failed to survive the trip, second, that the armies were taught to

lunge for the abdomen so that the bayonet would not be caught in the ribs and third, in case the bayonet was difficult to with-

pulse pressure confirm the cure. In the examination of the chest, it must be remembered that a peripheral injury will

	Total	White	Colored	
<u>Automobile</u>	19	11	8	
<u>Gunshot</u>	18	13	5	
<u>Industrial or Accident</u>	7	5	2	
<u>Hand Inflicted</u>				<u>Mortality</u>
<u>Dead on arrival</u>	22	4	18	8 or 3.5% and 13% for the admitted cases.
<u>Knife</u>	94	40	54	
<u>Ice pick</u>	57	9	48	
<u>Razor</u>	21	3	18	
<u>Hatchet</u>	1		1	
<u>Unknown</u>	58	3	55	
	297	88	209	

FIG. 1. Table of chest and stab wounds for one year.

draw to shoot it loose. During the Civil War, with much hand-to-hand fighting, there were reported in the Federal Records by Barnes<sup>5</sup> only thirty-eight sabre and bayonet wounds in a total of 246,712 wounded.

Superficial chest wounds, may involve only the skin and fascia or may extend through the muscles, ribs, and intercostal muscles and vessels to the parietal pleura. Not only do these wounds deserve careful examination, but a description of the injuring force or weapon and the direction of the force should be ascertained. This history is frequently unobtainable because of shock or fright, or both to the patient and the irresponsible statements of excited witnesses. The surgeon must work cautiously, unassisted by a history, to determine the extent of the wound.

The general condition of the patient and the physical findings in the chest may be an aid or delusion. It is often difficult to determine whether the rapid pulse is due to hemorrhage before arrival at the hospital, shock from an internal pneumothorax or the excitement of having been slashed by an irate husband or jealous wife. Morphine and reassurance may quickly cure what appeared to be an exsanguinated patient, and an adequate

cause a degree of splinting commensurate with the pain, and decreased expansion and respiratory sounds. Also, a definite atelectasis of a portion of the lung may be produced by an external blow.

The superficial wound should be carefully examined and, contrary to some authors (Head,<sup>6</sup> Davis,<sup>7</sup> and Everett<sup>8</sup>), explored, débrided and accurate hemostasis established. More care than is usual in soft tissue wounds should be used. The attendant dangers of any soft tissue wound—hematomas and infection—are present, but the danger of a hematoma or infection following a small opening inward through the constantly moving thoracic wall is the reason for most meticulous surgery. The usual patient with a stab wound has a dirty body and clothing and requires careful débridement.

The external bleeding from intercostal vessels is particularly disturbing and must be stopped. Instances of extrapleural but intrathoracic hematoma with marked exsanguination have been reported. The intercostal vessels themselves are usually well protected, particularly in the adult's lower chest, by lying in a groove on the inferior and inner aspect of the ribs. If the bleeding point is not seen by simply spreading the wound edges, strong retrac-

tion of the intercostal and the serratus muscles may bring the severed ends of the vessels into view. Should this fail, a sub-

openings and the presence of pleural adhesions. Graham (quoted by Bigger), has shown experimentally that if the size of the



FIG. 2. A, diagram of hemopneumothorax with compression of lung and displacement of heart from interpleural air and basal collection of blood. B, diagram of intrapulmonary type of bleeding with little heart displacement.

pleural suture may be passed around the entire rib above and below the site of the bleeding. As a last resort, a section of the rib must be removed without hesitation.

After closing the superficial wound, it is well to strap that region of the chest thoroughly. The strapping and immobilization are done for the patient's comfort and in an effort to prevent delayed bleeding, which is aided by the rhythmic movements of the chest.

Because many of these wounds are contracted in tetanus infected localities and are often puncture wounds in nature, the use of tetanus antitoxin should be made routine.

Deep wounds extend through the parietal pleural and the difficulties manifoldly increase. Should the external pleura alone be injured, there is the possibility of a pneumothorax. The amount of air will depend on the size of the opening through layers—the sucking wound. With the sucking in of air, blood from the external layers of the wound will also be drawn into the pleural space producing a hemopneumothorax. If the wound extends to the lung tissue, we have the possibility of both an internal pneumothorax and an external hemopneumothorax. (Fig. 2A.)

With the formation of the pneumothorax there is collapse of the lung. The extent of collapse will vary with the size of the

external opening equals the cross section of the bronchus, there will be an adjustment of pressure. However, the soft tissue may make a trap door which closes during expiration and the internal pressure will rapidly increase. This is particularly true when the lung is torn and the patient is coughing. The intrathoracic pressure of the cough is estimated to be as high as 87 mm. of mercury, by Starling,<sup>9</sup> and under such pressure considerable air is forced through even a small lung opening into the pleural space. Should adhesions attach the lung to the chest wall, these may be torn loose, giving a second internal opening or a secondary hemorrhage.

The rapid collapse of the lung and its compression against the mediastinum causes more or less cardiac displacement. The degree of displacement is modified by previous adhesions of the lung to the chest wall and mediastinal fixation. If there be little heart displacement, the compression of the lung against the thin veins and auricles may cause circulatory embarrassment. When the mediastinum is entirely without fixation, the heart may be markedly displaced and swing laterally from the great vessels with each respiration—a condition long recognized in thoracic work as pendulum shock.

Not only is the heart subjected to displacement and embarrassment, but in the presence of extensive pneumothorax, the

remaining lung is frequently robbed of an appreciable portion of its air. With the shallow respiration resulting from shock and pain, a portion of the air in the active lung is shifted back and forth into the dead space of the opposite bronchial tree. The Germans have called this phenomenon "pendle luft," and these patients may actually die from lack of oxygen.

The first treatment in deep wounds is to stop the sucking in of air. This may be accomplished by a few sutures, or if a large wound, by a temporary rubber dam placed over the opening to act as an externally discharging valve. The wound should be repaired as quickly as the patient's condition will permit, under an anesthesia during which a positive pressure may be maintained.

To prepare for surgery, the shock in these patients must be combatted. Morphine, heat and aspiration of the pneumothorax by a needle or valve are the best procedures. Intravenous solutions must be used with the greatest caution. This fact has been emphasized in complications following thoracoplasties, but has not been sufficiently applied to traumatic emergencies. If the patient is suffering from systemic shock, incident to trauma in which the pneumothorax is a minor part, intravenous support of the circulation may and should be used. If the condition is the result of cardiac embarrassment from lung compression and mediastinal displacement, increasing the burden on an already embarrassed right heart may result tragically. Intravenous solutions enter the right heart first, right ventricular pressure at best is only 15 to 20 mm. of mercury, and in the presence of traumatic pneumothorax the veins and right auricle are often struggling against air pressure greater than they can produce.

The immediate needs for severe pneumothorax are oxygen, which at times is supplied by the longer, deeper respirations following moderate doses of morphine, or directly by oxygen with a nasal tube, and a release of the collapsed lung from the

high intrapleural pressure. The pleural pressure may be released through an intercostal needle, any of the metal valves designed for this purpose, or a tube, inserted intercostally, with a slit finger cot tied over the end acting as a valve. The finger cot valve is less cumbersome than an outlet under water although the suction with the tube under water may be increased by lowering the receptacle. Of the three methods, the catheter inserted intercostally through a trocar and a slit finger cot tied about the distal end, allows a rapid release of pressure in the emergency room and its action can be easily observed.

Should the pneumothorax be complicated by bleeding, the fundamental compression of the lung remains the same but the treatment must be more active. Bleeding into the pleural cavity may be from the thoracic wall inward or from the lung or both. If from the thoracic wall, the intercostal vessels are the great offenders and must be ligated as soon as the patient's condition allows. Should the bleeding be from the lung, there are two sources, the bronchial arteries or the pulmonary vessels. Little attention in traumatic chest condition has been given the dual blood supply of the lung, although Bettman<sup>10</sup> has called attention to the pathological differences in the two circulations. Should the periphery of the lung and the pulmonary vessels alone be involved, there will usually be found a moderate amount of blood and a moderate pneumothorax. Both of these tend to compress the resilient lung tissue, to close the opening and to check the hemorrhage. The physical findings of hyperresonance, basal flatness and diminished or absent breath sounds are typical of the condition.

Because of the original low pressure of the pulmonary vessels and their early branching, the reduction to capillary pressure is rapid. The increased pressure of the pneumothorax will cause hemostasis in the moderate internal type of wound. If there is no evidence of cardiac embarrassment or signs of increasing hemorrhage,

the patient may be treated generally until about seventy-two hours has elapsed. This length of time allows small vessels to clot and gives an idea of the presence of primary contamination. An estimation of the amount of blood is attempted from the x-ray. In reviewing the films, it is well to remember that blood has a tendency to spread over the pleura and give an exaggerated picture (Wood and Eloesser<sup>11</sup>). Also, the pleura rapidly dilutes the blood with serous exudate to increase the fluid as compared with the first picture.

Following war experience, Morelli and Lilienthal advocated aspirating blood from the pleural cavity and replacing it with air. The method was met with considerable opposition by those of the profession who feared infection. While a portion (about 8 per cent) of all hemothorax cases will become infected, the majority of observers (Sontag,<sup>12</sup> Boland,<sup>13</sup> Sandison,<sup>14</sup> and Miller<sup>15</sup>) advocate aspiration and air replacement because: (1) series of cases fail to show a higher incidence of infection, (2) hospitalization is shortened, and (3) there is less residual pleural thickening and atelectasis of the lung tissue.

Later complications of lung injuries are empyema and abscesses with their long attendant difficulties, and acute respiratory infection. These must be treated as the case demands.

When a bronchial artery of medium size is severed, a very serious problem is presented. The bronchial arteries arising from the aorta receive the systemic pressure of the left ventricle. They accompany the main bronchi and their injury usually involves the bronchus. In these cases the bleeding is intrapulmonary. Gurgling, bronchial râles at first heard below the level of the wound are rapidly silenced as the alveolae are filled with blood. The percussion note is flat. There is usually little cardiac embarrassment or displacement. As the level of the blood rises into the bronchi immediately above the injury, coughing produces small amounts of bright blood. Aspiration usually obtains only a

few cc. of blood. However, should the rent in the peripheral lung tissue be large, the blood may find its way directly into the pleural cavity. In such a case aspiration of the blood and compression pneumothorax with air may be utilized. The patient is in no condition for exploration or lobectomy. When exsanguination is eminent and donors not available, autotransfusion of the aspirated blood directly into the median vein may be used. A 50 cc. syringe with an outlet stop cock, glass connections and rubber tubing make a satisfactory apparatus. The side opening of the stop cock is utilized for transfusion and air replacement.

The chest wound with bronchial artery bleeding and bronchial damage is the most difficult type and the least satisfactorily handled. With the lung tissue filled with blood, interpleural pressure with pneumothorax has little effect on the solidly filled organ as it is impossible to inject sufficient air pressure to stop any except a small bronchial vessel. Intravenous therapy will increase the blood pressure and the bleeding. Exploration for the bleeding vessel is impractical. Phrenicotomy, with the weight of the blood on the diaphragm, may cause its descent and increase the intrapleural area. Supportive measures and allowing the rise of the blood level within the lung tissue to compress the vessel is the best procedure.

If the bronchial vessel is small and only part of a lung involved, the patient may respond to the treatment of "masterful inactivity." Very slow resolution of the blood with a low (100°), constant temperature for about eight days may result. Six months later a narrowed atelatic shadow, slight diaphragm rise and emphysema of the lung above may be the only residua.

Should the intrapulmonary bleeding be massive (approximately two-thirds of a lung), recovery from the bleeding will be followed by a disappointing series of complications. A gangrene of the alveolar tissue results in a sepsis. This is usually



discernible at about the fifth to sixth day by a septic temperature, and leucocyte rise. Drainage, closed or open, has no appreciable results. Radical rib resection, removing large quantities of gangrenous material and packing and irrigating with various antiseptics, produce no results other than a bronchial fistula and the patient grows slowly more septic. For these reasons, I advocate lobectomy in the intrapulmonary type of bleeding at the first signs of sepsis. A diagram of the simple hemopneumothorax as compared with the intrapulmonary type of bleeding is seen in Figure 2.

#### CONCLUSIONS

1. Care must be taken in examining and repairing superficial chest wounds.
2. The immediate closure of deep chest wounds should be done and aspiration or valve control of internal pressure should be used.
3. The mistaking of systemic shock for right heart embarrassment and the danger in using intravenous solutions in the presence of increased intrapleural pressure is emphasized.
4. There is a difference in treatment and results of wounds involving the pulmonary and those involving the bronchial vessels.

5. Lobectomy or pneumectomy should be used in massive intrapulmonary hemorrhage at the first signs of sepsis.

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# DIAGNOSIS IN ABDOMINAL TRAUMA\*

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WHEN a traumatic lesion of the abdomen, due either to penetration or blunt violence, is suspected or known to exist, diagnosis embraces more than the mere determination of whether peritoneal perforation has occurred, and even more than estimation of the probable existence and extent of visceral injury. Upon a complete determination of the patient's status in respect to shock, hemorrhage, and associated injuries, depend both the selection and the timing of the therapeutic measures which have been discussed elsewhere.<sup>1,2</sup> In addition to immediate or preoperative studies, observations at the time of operation, and recognition of the late complications which follow traumatic lesions of the abdomen, are still other important phases of diagnosis.

An account of the circumstances under which the injury was incurred, as well as a description of the mechanism of the injury, often furnish valuable information. (Fig. 1.) For instance, in considering the possible damage done by a blunt force or by a projectile following a known course, if the urinary bladder was recently emptied it may escape injury; while if distended at the time the wound was sustained, the bladder may not only have been struck but is likely to have been extensively lacerated as a result of the explosive force exerted by its noncompressible fluid contents. (Fig. 2.) Likewise, evacuation of the bowel shortly before injury favorably influences the amount of spillage of intestinal contents. The physical attitude of the patient when wounded may greatly influence the course of a projectile, and in the instance of subcutaneous wounds, the type and direction of the blunt force often suggests the prob-

able location of visceral lesions. Information concerning the period of time elapsed since the injury was sustained, and the character of first aid or other previous treatment is also of value in planning the management of patients with abdominal injuries.

Prompt determination of the existence of abdominal visceral injury, extensive hemorrhage, shock, or associated chest as well as craniocerebral injury is especially necessary when patients are to be transferred in airplanes flying at high altitudes. Lovelace<sup>3</sup> has reported on the deleterious effects caused by reducing atmospheric pressure in the presence of any of these conditions, and has also drawn attention to the increased outpouring of stomach and intestinal contents caused by expansion of gas in these viscera when atmospheric pressure is lowered. Only those ambulance air transports which have cabins that can be sealed to permit maintenance of barometric pressure near that at ground level are safe conveyances for seriously wounded patients.

## SYMPTOMS

*Pain.* Pain which follows traumatic lesions of the abdomen is not constantly and directly related to the existence, location or extent of visceral injury. Usually experienced immediately, its onset may be delayed for several minutes, or even several hours, either because of excitement at the time of the injury, or, more often, because pain following abdominal injuries is not due so much to visceral damage as it is to peritoneal irritation caused by blood or the spilled contents of hollow viscera. The extravasation of acid stomach juice may

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immediately cause sudden severe, diffuse pain, while perforation of the cecum, with spillage of only a small amount of solid or

dependable symptom. Trauma to the lumbar plexus sometimes causes pain in the corresponding lower extremity, so that

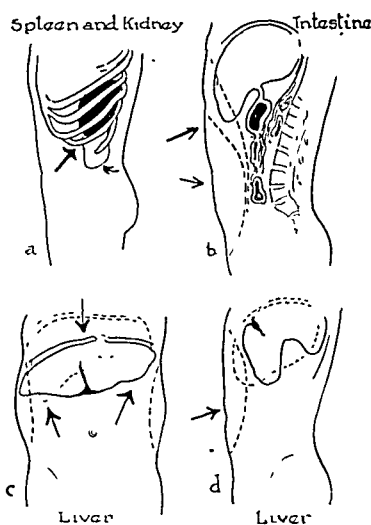


FIG. 1.

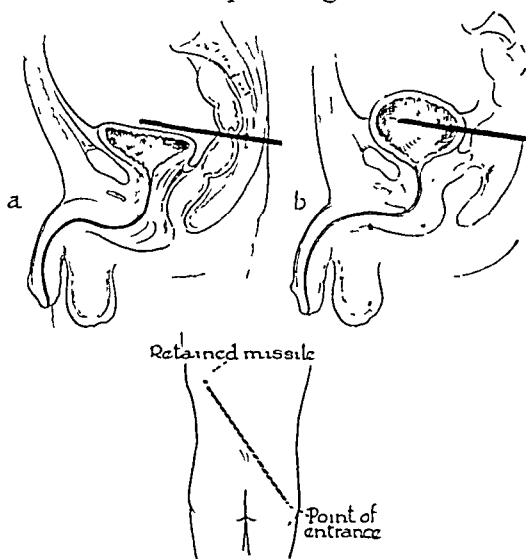


FIG. 2.

FIG. 3.

FIG. 1. Diagrams illustrating the mechanism of subparietal injuries to abdominal viscera due to the blunt forces indicated by arrows. The fixation, location, size, and turgor of the liver and, to a lesser degree, of the spleen and kidneys make them particularly susceptible to injury. Fixation by a mesentery or by a vascular pedicle is an important element in the mechanism of injuries to hollow viscera which are caused by blunt violence. In addition to the compression injuries caused by motor vehicle steering wheels or by intact ribs, broken steering wheels and fractured ribs may cause penetrating wounds.

FIG. 2. Diagrammatic illustration showing how, depending on whether it is empty or filled, the bladder may or may not escape injury by a missile traversing a given track. When a projectile strikes a distended bladder an "explosive" or "bursting" type of injury may be produced as a result of the incompressibility of the fluid bladder contents.

FIG. 3. Diagram indicating the intraperitoneal course of a missile which has entered at a point remote from the abdominal wall. Abdominal viscera are frequently injured by missiles which enter through the buttocks, perineum, thigh and thorax.

semisolid material, may be followed by practically no discomfort, especially if there is no associated intraperitoneal hemorrhage. Soldiers with extensive wounds and even with evisceration of abdominal organs have often continued in action, and both soldiers and civilians with such injuries may walk considerable distances after being wounded.

Pain following injuries limited to the abdominal wall may be greater than that which sometimes exists when the peritoneum has been penetrated. A localized painful area distant from the point of entrance may, when there is no wound of exit, indicate the region in which the missile is lodged, but this is a rare and un-

the injured individual may consider that his wound primarily involves the thigh or leg rather than the abdomen. When large objects bluntly injure the abdomen, the sensation experienced is similar to that produced by any violent blow. Small projectiles can cause a sensation as if a blow had been sustained by a large object, but the sensation usually produced by them is sharp or stabbing.

Pain may be either transient or persistent, and may be accompanied by collapse. When intestinal evisceration has occurred, there may be cramping pain due to peristalsis; but this is often not the case, because of the usually rapidly developing adynamic ileus which involves the extruded

loop as well as that portion of the bowel which has remained within the abdomen. Pain referred to the root of the neck may be due to intraperitoneal hemorrhage or to the subdiaphragmatic accumulation of gas which has escaped through a perforation of the stomach. There is ordinarily not sufficient gas either in the small or the large intestine to produce this symptom.

Injuries in other parts of the body sometimes so completely direct attention to these parts that the pain due to the abdominal injury is overlooked. Whether the patient has or has not received morphine must also be taken into consideration in assaying pain.

*Nausea and Vomiting.* The presence or absence of nausea and vomiting does not indicate whether or not intraperitoneal injury has occurred. The degree of these symptoms may be modified by the injured person's normal tendency to become nauseated and to vomit. These symptoms may follow injury to practically any abdominal area or viscus, particularly the stomach, esophagus and kidneys, but they may be absent, regardless of the location or character of the wound, the amount of spillage of alimentary tract content, or the extent of either intraperitoneal or extraperitoneal hemorrhage. Contrary to what might be expected, hematemesis often does not accompany stomach injuries.

*Miscellaneous Symptoms.* Air hunger is usually experienced by patients who have suffered considerable blood loss, and when hemorrhage has been extensive, air hunger may even be evident to the examiner. Dyspnea, most often observed following abdominothoracic injuries, may be pronounced even though no chest injury exists.

Bladder or rectal tenesmus may follow urinary bladder or rectal wounds, respectively, and one or more bowel movements sometimes occur shortly after the injury. The material excreted by bowel may contain or be coated with blood, but early spontaneous hemostasis often prevents the appearance of gross amounts of blood, and

in any event, the passage of blood by rectum is rarely observed by the injured person. Varying degrees of hematuria may be noted by the patient, but the suppression of urine which frequently follows injuries to the urinary tract may cause considerable delay in the appearance of hematuria.

#### PHYSICAL EXAMINATION

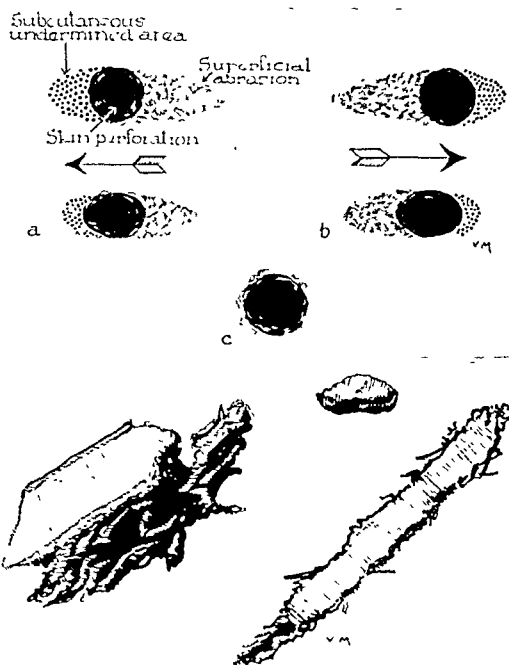
A general physical examination, even quickly performed, can not only reveal injuries unrelated to possible abdominal trauma, but permits detection of wounds produced by missiles which enter the abdomen via the buttocks, thighs, perineum or thorax. (Fig. 3.)

#### INSPECTION

*General Appearance.* Patients with abdominal wounds usually seem ill in proportion to the extent of their injuries, but this relationship is influenced by the time which has elapsed since injury, by variations in reaction to an equal degree of pain, and by the amount of associated shock and hemorrhage. A calm facial expression, perfect composure and animated interest in the surroundings may reflect a phlegmatic disposition and can be misleading. The appearance of the patient is also affected by such first aid attention as the administration of morphine and the application of external heat. There may be extreme restlessness or excitement, but more frequently, the patient is either quiet, drowsy or even apathetic. Especially in the instance of soldiers, because of loss of sleep or sustained physical and psychic tension, a desire to secure rest and to sleep may supercede any concern about the wound. The color may be good, or there may be some pallor, and occasionally even cyanosis, especially if there is also a chest injury. Perspiration is frequently profuse. Dyspnea and rapid respiration are usually present when there is an accompanying thoracic lesion. Air hunger may be detectable by inspection.

The abdomen usually reveals a diminution or absence of the movement which

normally occurs synchronously with respiration. Although breathing which is either entirely or principally thoracic in



FIGS. 4 AND 5.

FIG. 4. Above. Drawing illustrating various types of external wounds in relation to the courses taken by bullets. A concentric area of abrasion and contusion indicates that the bullet has taken a straight course. If the area of abrasion is to the right of the edge of the wound, it signifies that the missile has passed from right to left, and vice versa if the area of abrasion is to the left of the edge of the wound. Furthermore, the amount of undermining beneath the edge of the wound opposite the area of abrasion may also indicate the obliquity of the course of the missile.

FIG. 5. Below. Fragments of high explosive shells used in the present European War. Various-sized fragments of this sort, along with bullets, are responsible for most of the wounds in contemporary warfare. Because of their irregular shape, fragments of high explosive shells cause ragged lacerations, and the larger fragments are especially likely to be retained if traveling at low velocity.

type may be observed when the injury is limited to the abdominal wall, the absence of abdominal excursion suggests that there is intraperitoneal extension of the wound.

A bluish area may occasionally be seen in the region of the umbilicus when there is a large amount of blood in the peritoneal cavity. Inspection of the abdominal

parietes anteriorly, laterally and posteriorly, in addition to furnishing information concerning the wounds of entrance or exit, may also reveal external bleeding, or the discharge of urine or feces. A plug of omentum in or protruding through a wound at once reveals that the peritoneum has been perforated. A knuckle or loop of either intact or injured intestine, or a portion of the stomach, spleen or liver sometimes is found projecting into or completely through the parietal wall wound. Occasionally, a bullet or shell fragment can be seen in an open wound, and projectiles lying beneath the skin often can be detected by the bulging of the skin which they cause, especially when surrounded by a hematoma. Subcutaneous rupture of an abdominal wall muscle may be indicated by a hematoma at the site of injury.

Bulging of the flank, caused by outpouring of blood and intestinal content, may be evident. Abdominal distention and a corrugated appearance produced by distended intestine are observed only after the onset of ileus or peritonitis. When the spinal cord is injured, distention of the urinary bladder may be detected.

Study of entrance and exit points or even of an entrance wound alone can help in determining whether peritoneal penetration has occurred.<sup>4</sup> The entrance wound produced by a bullet is almost invariably smaller than the caliber of the bullet, while the wound of exit is usually larger than the caliber of the bullet and these wounds are frequently irregular. A concentric area of abrasion and contusion surrounding the point of entrance indicates that the bullet has taken a straight course, and that viscera in the region have probably been injured. A superficial abraded area to the side of the wound signifies that the missile has approached from that side. Obliquely directed bullets undermine the skin opposite the area of surface abrasion and, since the areas of contusion and undermining are increased with the obliquity, the more superficial the bullet tract, the larger the superficial contusion and the

greater the undermining. (Fig. 4.) These observations are important in estimating the extent and direction of superficial, non-ularly grave sign is semierrection of the penis, which is reported to be always followed by death.

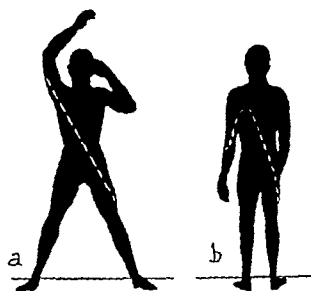


FIG. 6.

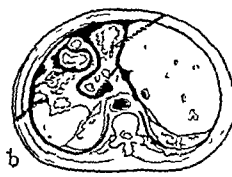
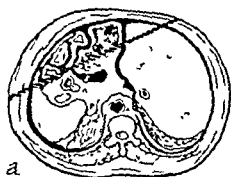


FIG. 7.

FIG. 6. Diagrams indicating how variation in the relative position of parts of the body may make it appear that a missile has taken an extremely erratic course. (a) Indicates the position of the patient at the time of injury; (b) indicates how an impression of a bizarre course of the missile might be gained from studying the wound track while the patient is lying on an operating table.

FIG. 7. Diagrammatic representation of the shift in the relative position of abdominal viscera and wound tracks caused by a change of posture or by respiration.

penetrating bullet wounds of the abdomen, which cause pain and at times nausea, vomiting, tenderness and rigidity. Wounds produced by the irregular or jagged projectiles responsible for many of the injuries in modern warfare (Fig. 5), yield less definite information than can be obtained when wounds are caused by bullets.

The apparently bizarre course of projectiles frequently ascribed to deflection or ricocheting is often really due to the patient's bent over, crouched, or partially turned position at the time of the injury. Difficulty in accounting for the location of some visceral wounds found when the patient is lying on an operating table may be due to a shift in the position of organs from that which existed at the time of injury. (Fig. 6.) Furthermore, a shift in the relative position of viscera after injury has occurred, and during various phases of respiration sometimes explains the apparently erratic courses of missiles. (Fig. 7.)

In the condition termed *muerte subperitoneal* (subperitoneal death) described by Bastos,<sup>5</sup> there are premonitory symptoms of coldness of the extremities, cold sweats, cyanosis, feeble and rapid pulse, but no accompanying signs of peritonitis. A partic-

#### PALPATION

*Palpation of the Skin.* Except when there is elevation of temperature due to peritonitis or wound infection, the skin is usually moist and cool. Subnormal surface temperature is frequently accompanied by subnormal oral and rectal temperatures.

*Pulse.* The pulse is frequently rapid and thready, but a slow pulse does not necessarily indicate that serious abdominal injury is not present. Bradycardia may occasionally result from the absorption of bile which has been extravasated into the peritoneal cavity following liver or biliary tract injuries. Visceral perforation, particularly when involving hollow viscera, and if unassociated with hemorrhage, shock, or infection, may not cause an increase in rate or impairment of quality of the pulse. The prognosis is usually good when the pulse rate does not exceed 100 beats per minute, while many patients with a pulse of 120 or higher die. A rapid pulse when the patient is first seen may not be entirely due to shock and hemorrhage, since pain or excitement may contribute to causing the acceleration. Considerable slowing of the pulse often follows even a short period of rest and quiet. It has been suggested that a persistently rapid pulse or an increasing

pulse rate are indications for operation, but changes in the pulse are frequently a relatively late indication of the existence and progress of shock and hemorrhage.

*Tenderness.* Evaluation of abdominal tenderness is often difficult. Tenderness due to a wound of the abdominal wall is ordinarily localized, while tenderness due to visceral injury and extravasation of blood or fluid gastrointestinal contents is usually diffuse. If only a small amount of solid or semisolid feces spills into the peritoneal cavity, there may be little or no tenderness. A tender tract may be sometimes traced, corresponding to the course of the missile in the abdominal wall, and an area of localized or circumscribed tenderness may indicate the resting point of a missile in the abdominal wall or within the abdomen. Tenderness is sometimes due to distention of the urinary bladder.

*Rigidity.* The degree and location of rigidity can lead to an incorrect estimation of the patient's condition in respect to abdominal penetration or visceral injury. Abdominal rigidity frequently accompanies low thoracic injuries, and is usually associated with wounds of the abdominal wall, the pelvic floor and even of the thigh. The amount of blood or urine, as well as the character and volume of spilled gastrointestinal contents determine the degree and extent of rigidity. Extravasation of solid intestinal contents may be followed by undetectable rigidity, while even a small amount of acid gastric juice is likely to cause diffuse board-like rigidity.

The following observations concerning rigidity in abdominal casualty cases have been recorded by Wallace:<sup>6</sup> (1) Rigidity may be slight and may be either general or local. (2) It may be confined to one part or it may become diffuse, generally indicating an intestinal lesion. (3) There may be alternating presence and absence of rigidity, a finding sometimes accompanied by extensive injuries. (4) The term "apprehensive rigidity" has been applied to the condition in which the abdomen looks soft and moves on respiration, but hardens

when the hand approaches to palpate. As a rule, it is accompanied by no serious injury. (5) Board-like rigidity, when accompanied by extreme pain, nearly always indicates that there is a wound of the gastrointestinal tract. (6) Complete absence of rigidity is often a very bad sign, although a lax abdomen may exist with hollow visceral lesions and the patient be in good state. (7) Morphia in moderate doses seems to have very little effect on the state of the abdominal wall.

Palpation of the abdominal wall, the lower chest wall, the buttocks and the upper parts of the thighs may reveal a missile lodged superficially either near the entrance wound, or in an area where a wound of exit would have occurred had the projectile travelled slightly farther. Subcutaneous rupture of the abdominal wall caused by blunt force may be revealed by palpation of a gap in a muscle, usually with a surrounding hematoma. The detection of crepitation may, in early cases, be due to subcutaneous emphysema following a thoracic wound, while crepitus in late cases may be due to gas bacillus infection. Occasionally, the diffusion of air trapped beneath a flap of soft tissue, as well as the diffusion into the parietal wall of gas which has escaped through a stomach perforation, is responsible for crepitation in the abdominal wall, and this sign may also occasionally be detectable over an abdominal wall hematoma. Ballotement indicates the accumulation of the peritoneal cavity of blood, gastrointestinal contents, or in late cases, fluid inflammatory exudate. Rectal examination is an important part of the physical examination and may reveal injury to the colon, rectum or anus. Rectal examination is especially important when the wound of entrance is located in the gluteal, sacral or perineal region. Not only may a perforation of the anorectal region be felt, but blood on the gloved finger will disclose bleeding from a wound of the colon even above the reach of the examining finger.

*Percussion.* Absence or diminution of relative or absolute liver dullness may be

caused by free gas in the peritoneal cavity. The absence of this finding even though a gas-filled hollow viscus has been perforated, is sometimes due to the external escape of gas through the abdominal wall wound, while in other instances, the amount of gas which escaped is insufficient to produce the sign. In the presence of peritonitis, gas in the peritoneal cavity may be due to the activity of gas producing bacteria. Percussion may also reveal abnormal dullness in the flank, or shifting dullness due to the presence of blood or other fluid in the peritoneal cavity.

*Auscultation.* There is seldom an occasion of auscultate the abdomen of patients with recent abdominal injuries. In late cases, however, the so-called "silent abdomen" may indicate the onset of ileus or peritonitis.

*Temperature.* Oral, rectal or axillary temperature is often subnormal because of shock and hemorrhage and is sometimes as much as two degrees below normal. Elevation of temperature usually indicates peritonitis or other infection, although it may be due to the extravasation of blood either in the abdominal wall or into the peritoneal cavity.

*Blood Pressure.* Attempts have been made to establish blood pressure criteria which could be applied in judging cases with abdominal injury, especially in respect to operability and the optimal time for operation. A systolic blood pressure of 80 has been suggested as the level below which operation is inadvisable. Lowering of the blood pressure is usually paralleled by a rise in pulse rate, but like the pulse, as an indicator of the degree or continuance of hemorrhage, blood pressure changes are undependable, because fatal hemorrhage may occur before they reflect reduction in the volume of circulating blood. Nevertheless, frequently repeated blood pressure determinations often furnish information of value in the management of abdominal casualty cases.

A method which was suggested and employed by some surgeons during and after

World War I, in an attempt to "differentiate shock from hemorrhage" is described here only to be condemned as unreliable and unsafe. It consisted of making blood pressure observations following the administration of a hot infusion, which it was contended would cause a rise in blood pressure only if shock was due to hemorrhage.

#### CLINICAL LABORATORY STUDIES

*Examination of Urine.* Routine gross or microscopic examination of the urine frequently reveals injuries to the urinary tract not suspected on the basis of the projected course of the missile or from the location and nature of a blow. Absence or delay in the detection of hematuria may result from severance or obstruction of a ureter as well as suppression of urine which sometimes follows injuries to the urinary tract.

*Hematologic Studies.* Since changes in the composition and physical character of the blood depend not only on the rate, duration and total volume of blood loss, but are also influenced by concomitant traumatic shock due to tissue injury, and parenteral fluid therapy, blood studies following abdominal trauma often reveal only slight or confusing deviations from the normal. A degree of shock disproportionate to that which follows the external loss of a given amount of blood often occurs when the blood is spilled into the peritoneal cavity. The intraperitoneal outpouring of fluid in response to the presence of the blood, coupled with the loss of blood fluid into the tissues tend to cause hemoconcentration and this trend in the composition of the blood can mask the actual loss of red blood cells. The loss of fluids from the blood often exceeds the movement of fluids into the blood in the effort of the organism to restore and maintain blood volume. Therefore, depending on the amount, rate and duration of hemorrhage, and the degree of associated traumatic shock, as well as the fluid administered parenterally, the blood of



patients with abdominal injuries may be concentrated, diluted or practically unchanged in composition.

Red blood cell counts and hemoglobin index determinations, even though repeated after short intervals, are usually not dependable indications of either the amount or the trend of intraperitoneal bleeding, as changes in them do not occur until there has been great blood loss. Significant lowering of the red blood cell count and the hemoglobin index are ordinarily preceded by clinical evidence of continued hemorrhage.

An early and sometimes considerable increase in the blood leucocyte count may occur as a result of the presence of blood in the peritoneal cavity.

Although even repeated hematologic surveys sometimes fail to show the degree or even the trend of intraperitoneal hemorrhage, the demonstration of changes in the relative cell volume by the hematocrit method, and the estimation of the specific gravity of the blood plasma or of the whole blood either by Hammerschlag's method,<sup>7</sup> or by the Barbour and Hamilton falling drop apparatus,<sup>8</sup> usually permit rapid and early detection of the concentration changes associated with shock due to hemorrhage.<sup>9</sup>

Not only are mean corpuscular volume and blood specific gravity studies of value in the diagnosis and immediate therapy of patients with abdominal injuries, but these tests for dehydration and plasma protein depletion are of great assistance in the subsequent management of such cases.

*Bacteriological Studies.* Examination of direct smears and culture growths made from the edges of wounds or from wound exudate, furnish information which may be valuable in choosing appropriate chemotherapeutic or bio-immunologic agents in the prophylactic treatment of peritonitis and wound infection. In studying wound contamination by cultural methods, it is important that anaerobic as well as aerobic cultures be made.

#### X-RAY EXAMINATION

When missiles are retained within the abdomen or when there is a possibility that more than one projectile has entered either the abdomen or the abdominal wall, fluoroscopic or roentgenographic examinations are of obvious value, especially in military practice, since many of the wounds in modern warfare are caused by low velocity projectiles which are retained. The use of a portable x-ray apparatus is often desirable in order to avoid moving the patient, and under some circumstances, x-ray examination is best done in the operating room. In addition to furnishing information of value in planning the operative incision in relation to a retained missile, the x-ray examination may reveal gas beneath the diaphragm, the existence of a diaphragmatic hernia, or reduced diaphragmatic excursion. The absence of gas beneath the diaphragm even though a gas-containing hollow viscus has been perforated, may be due to escape of the gas through the abdominal wall wound or to the small amount of gas contained in the perforated viscus. Roentgenography of the thorax often discloses chest lesions which must be taken into account in the management of the abdominal injury. Fluoroscopy ordinarily supplies sufficient information in less time than is required for roentgenography, but when more than fluoroscopic examination is necessary, anteroposterior and lateral roentgenograms usually permit satisfactory localization of foreign bodies. Stereoscopic radiograms, however, are sometimes more informative than are single projections. If precise localization is required, this can be accomplished by one of several methods devised for this purpose.

Skiagraphic observations made in a darkened operating room with the aid of a fluoroscopic bonnet, are seldom necessary during operations for abdominal injuries. The method of intermittent fluoroscopic control was found to be more satisfactory in World War I for general use in the extraction of metallic foreign bodies than were electrovibrators, telephone probes, or other

similar devices, because approximately one-fifth of the foreign bodies were not magnetizable.<sup>10</sup>

Pyeloureterography following the intravenous injection of x-ray opaque solution, as well as cystography following the injection of x-ray opaque solution into the bladder, are helpful means of detecting not only the existence but the extent of injuries involving the kidneys, ureters and bladder.

#### ENDOSCOPIC EXAMINATION

Endoscopic examinations are occasionally useful when other methods fail to furnish conclusive data in patients with abdominal injuries. Proctoscopy or sigmoidoscopy may disclose an injury of the terminal portion of the large bowel, either by affording visualization of a wound which is beyond the reach of or not detectable by the examining finger, or by merely revealing the presence of blood. Esophagoscopy and gastroscopy may, under some circumstances, be employed when injury to the esophagus or the stomach is suspected. Cystoscopic examination, although not satisfactory when the bladder has been perforated, may in the presence of an intact bladder permit detection of bleeding from a ureteral orifice. Furthermore, the preoperative introduction of a large catheter into the ureter from which bleeding has been observed facilitates its repair after the abdomen has been opened.

#### PERITONEOSCOPY

This method of examination, which has been the subject of several reports by Hamilton,<sup>11</sup> has been suggested as a possible aid in diagnosis in cases with only suspected penetration of the abdominal wall. The peritoneoscope is introduced through a small incision, and the areas of the parietal peritoneum through which perforation might possibly have occurred are surveyed. If a perforation of the abdominal wall is found, exploration should be done even though no blood, gastrointestinal contents, bile, or urine is found, as it is not safe to depend upon peritoneo-

scopic examination to determine whether or not visceral perforation has occurred. Hamilton,<sup>12</sup> has recently described an apparatus which can be introduced through the peritoneoscope to permit manipulation or movement of viscera, thus increasing the range of usefulness of peritoneoscopy.

#### DETERMINATION OF PENETRATION BY EXPLORATION

*Exploration of the Wound.* When complete penetration of the abdominal wall is in doubt, it may be possible by means of a pair of blunt forceps, used as a probe, to determine whether or not the perforation extends through the parietal peritoneum. However, when a wound extends obliquely for a considerable distance in the abdominal wall, a shift in muscle, fascia, or fat may make it impossible to follow the wound throughout its entire extent, so this method of examination is not always dependable. Although the probing of wounds has been deprecated, much valuable information may sometimes safely be obtained by this simple method.

Another procedure which may be employed when there is uncertainty concerning perforation of the peritoneal membrane, consists of making an incision down to the peritoneum near the entry wound in the abdominal wall, and then, by peeling away the peritoneum in the region of the wound, the presence or absence of peritoneal perforation usually can be determined.<sup>13</sup>

*Exploration through a Small Incision.* The introduction into the rectovesical space of a sponge on a long sponge holder, through a small suprapubic incision, for the purpose of determining the presence or absence of blood, gastrointestinal contents, bile, or urine has been employed when doubt has existed concerning abdominal wall or visceral perforation. Although this method may at times demonstrate intraperitoneal injury which cannot be ascertained by other means, it is essential that no blood be allowed to enter the abdomen through the intentionally made suprapubic incision. Furthermore, this

method is not dependable when there has been extraperitoneal injury of a viscus, and even in the instance of intraperitoneal

injuries may escape detection even when exploratory laparotomy is done.

Although blood, and less frequently ex-



FIG. 8.

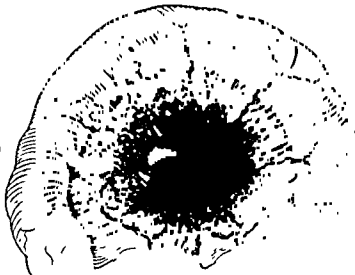


FIG. 9.

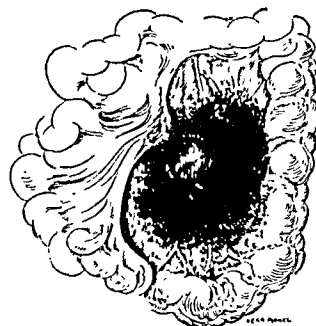


FIG. 10.

FIG. 8. Hematoma located near the junction of the mesentery with the intestine. Hematomas in this location sometimes extend beneath the serous coat of the bowel and should be incised as they may obscure an intestinal perforation. The injury to terminal vasa recta responsible for the formation of hematomas in this position occasionally causes such a degree of ischemia of a small segment of adjoining intestine as to necessitate intestinal resection.

FIG. 9. Hematoma located in the central zone of the mesentery. Because of the opportunities for collateral circulation, small-sized hematomas in this region are not likely to be associated with serious impairment of the blood supply to the nearby intestine, and they should usually be left alone. However, if a hematoma in this position is of large size and especially if it can be seen to be enlarging or if there is active bleeding through an opening in it, it should be opened widely and a search made for the unarrested bleeding point.

FIG. 10. Hematoma located between the leaves of the sigmoid mesentery. Hematomas resulting from injuries to the large branches of the superior or inferior mesenteric arteries near the root of the mesentery sometimes extend over a large area in the retroperitoneal space, even reaching into the pelvis. Under such circumstances, location of the bleeding point is difficult or impossible, and because of the danger of exposing the retroperitoneal space to infection and the possibility of causing more blood vessel injury, search for the torn vessel should usually be done only when it is believed or known that a damaged vessel is still bleeding.

injuries of the large intestine, there is often so little hemorrhage, and the intestinal contents may be of such solid consistency and small amount that gravitation of blood or feces into the rectovesical space may be long delayed or even may never occur.

*Exploratory Laparotomy through a Large Incision.* When doubt exists despite the employment of other methods for determining whether or not there has been peritoneal perforation or visceral injury, early exploration is usually safer than prolonged observation and conservative treatment. Even though a gas-filled hollow viscus has been perforated there is usually an absence of the hissing sound often heard when the peritoneum is opened following rupture of a peptic ulcer, the gas having already escaped through the abdominal wall wound. Because of an obscuring hematoma (Figs. 8, 9 and 10), inaccessibility, or the haste with which operation is done, visceral

travasated gastrointestinal contents, may be found as soon as the peritoneum is incised, the location of the injury may be so distant, or the amount of free fluid in the part of the abdominal cavity first brought to view may be so small that until the incision has been enlarged and exploration has been carried farther, it is not possible to determine whether there has been visceral injury. Partial mobilization of the duodenum or of fixed segments of the large intestine, and examination of the posterior surfaces of the stomach and the transverse colon after opening the lesser peritoneal cavity, may be required to expose retroperitoneal or other hidden injuries. (Figs. 11, 12, 13.)

#### WOUNDS OF SPECIFIC ORGANS OR STRUCTURES

Several generalities concerning the likelihood of injuries to various organs are well

known. Injuries caused by blunt force, especially when directed against the upper portion of the abdomen or the lower chest,

in respect to fixation of the several portions of the large intestine, as well as the proximity of some parts of the colon to the bony

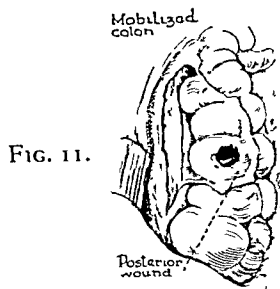


FIG. 11.

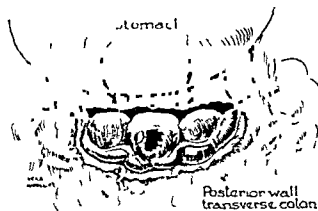


FIG. 12.

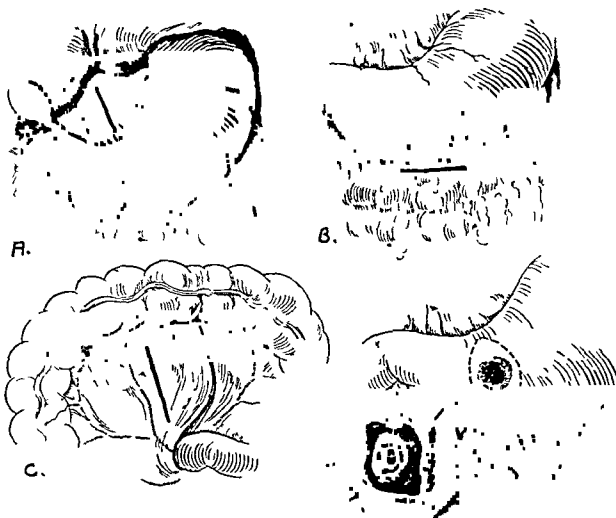


FIG. 13.

FIG. 11. Partial mobilization and reflection of the ascending colon to reveal a retroperitoneal perforation.

FIG. 12. Partial mobilization and rotation of the transverse colon to reveal a perforation on its posterior aspect.

FIG. 13. Various methods of exposing a wound of the posterior wall of the stomach. Shown in (A), (B) and (C) are incisions for opening the lesser peritoneal cavity. Exposure of a posterior wall injury by an opening in the anterior stomach is shown in (D).

often involve the liver, the spleen, the kidneys or the diaphragms, which structures, because of their turgor, size, fixation, and the presence of overlying ribs, are particularly vulnerable. The position and fixation of the duodenum and the pancreas make these structures susceptible to injury by anteriorly directed blunt forces. The stomach, by virtue of its size and comparative immobility, is likely to be injured either by projectiles or by blunt force. The small intestine, although relatively mobile, is, by its very extent, subject to injury, especially perforating wounds. Variations

in the frequency of injuries to this segment of the alimentary tract.

*Wounds of the Abdominal Wall.* Wounds in which a missile or sharp object pierce the abdominal wall without causing either hollow or solid visceral injury may result fatally either because of hemorrhage or peritonitis. Signs and symptoms which are either suggestive or definitely indicative of peritoneal irritation are likely to exist as a result of the presence of blood or of the occurrence of peritonitis, and it is often only by direct exploration that the absence of visceral injury can be determined.

**Esophagus.** Wounds of the lower end of the esophagus are usually associated with thoracic injuries. Persistent nausea

and vomiting may accompany a lesion of the esophagus, but there are no characteristic signs or symptoms to indicate esophageal injury, and recognition usually depends on projecting the course of the missile or instrument causing injury, or upon exploration. Damage to the esophagus may be revealed by esophagoscopy examination, but this method of diagnosis is ordinarily not feasible or satisfactory.

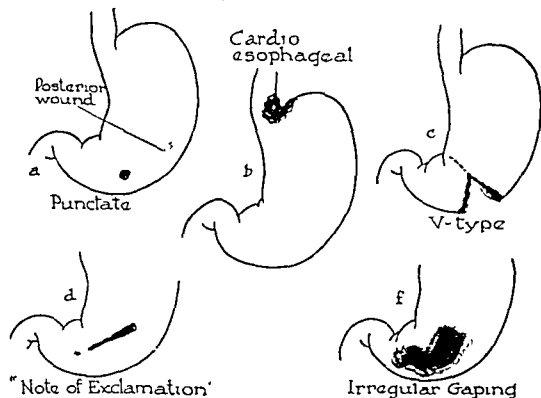


FIG. 14. Diagrammatic representation of some of the more common types of stomach wounds.

and vomiting may accompany a lesion of the esophagus, but there are no characteristic signs or symptoms to indicate esophageal injury, and recognition usually depends on projecting the course of the missile or instrument causing injury, or upon exploration. Damage to the esophagus may be revealed by esophagoscopy examination, but this method of diagnosis is ordinarily not feasible or satisfactory.

**Stomach.** Stomach wounds comprised about 7 per cent of all abdominal injuries coming to the hospitals during the 1914 to 1918 World War.<sup>10</sup> Two-thirds of the gastric lesions were unaccompanied by other visceral injury discoverable at operation. Other organs most frequently injured were: the small gut, liver, colon, kidney and the spleen, in the order named. Some of the more common types of stomach wounds are shown in Figure 14.

The wounds are usually two in number, and are most frequently situated on the anterior and posterior walls. If the anterior opening is small, and if the organ was not distended at the time of injury, there may be no protrusion of the mucous membrane and no escape of gastric contents. Leakage may occur into the lesser sac, even when none is present anteriorly. If but a single wound is present, it is usually located on the anterior wall.

There are no distinctive signs or symp-

stomach contents has spilled into the peritoneal cavity. Severe vomiting and

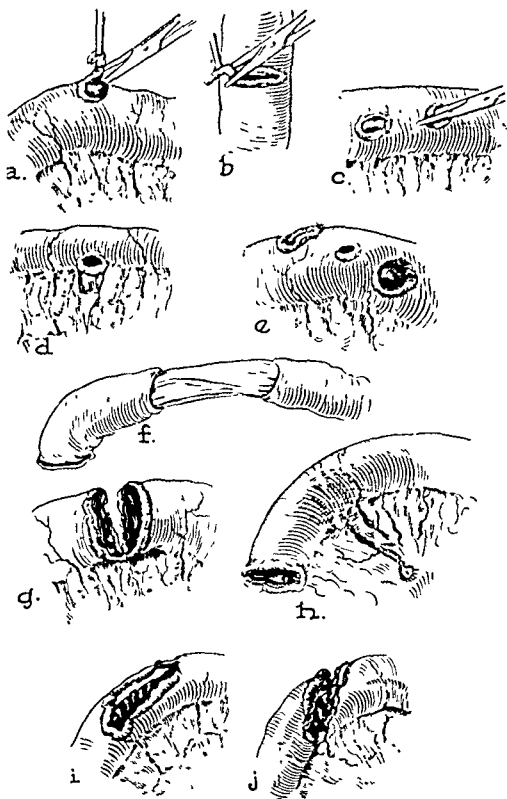


FIG. 15. Various types of small intestinal injuries.

(a) Single punctate wound which may be closed by purse-string suture after removing everted mucosa. (b) Single transverse lacerated wound. (c) Closely situated punctate wounds which may be communicated and then closed as a single wound. (d) Wound at junction of mesentery with intestine. Such wounds may be obscured by a mesenteric hematoma. (e) Multiple punctate and lacerated wounds. In most instances, these should be closed individually. Resection of the bowel for such injuries should be done only when separate closure of the perforations is not feasible. (f) Injury in which mesentery has been torn away and muscular coats stripped back. (g) Practically complete division of the bowel. This type of injury may be produced even when a comparatively small missile strikes a collapsed loop. (h) Wound of the mesentery with thrombosis of vasa recta and infarction of bowel wall. (i and j) Extensive lacerated wounds of the sort which sometimes necessitate resection of a small segment of intestine. The extent and character of hollow viscera wounds caused by projectiles is determined not only by the size and shape of the missile, but by the distention or collapsed state of the viscus at the time of injury.

nausea may accompany gastric wounds, but these symptoms may be absent, and hematemesis is unusual following stomach

shows several types of small intestinal wounds.

No characteristic symptoms are asso-

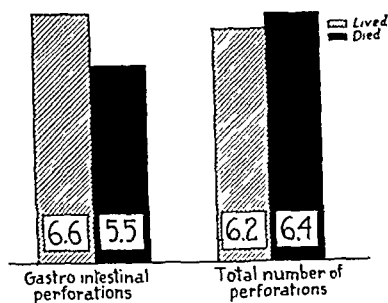


FIG. 16.

FIG. 16. Graphic representation of the average number of visceral perforations in relationship to the mortality in a series of forty-six penetrating bullet and stab wounds of the abdomen. Comparison of this Figure with Figure 17 reveals that the mortality is more directly related to the degree of hemorrhage than to the number of perforations.

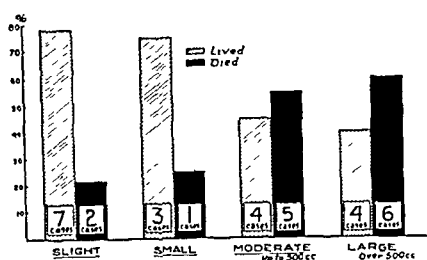


FIG. 17.

FIG. 17. Graphic representation of the direct relationship between the amount of hemorrhage and the mortality in a series of cases with penetrating bullet and stab wounds of the abdomen. Comparison of this Figure with Figure 16, which latter shows the average number of perforations in relationship to mortality, emphasizes the importance of hemorrhage rather than the number of perforations in determining the outcome in penetrating abdominal wounds.

injuries. When there has been extravasation of stomach contents, tenderness and rigidity can usually be detected. If a sufficient amount of gas from the stomach wound is retained in the peritoneal cavity, percussion reveals obliteration or reduction of the normal areas of liver dullness. It may also be possible to demonstrate the free gas in the peritoneal cavity by x-ray examination.

*Small Intestine.* The proportion of small intestinal wounds, both complicated and uncomplicated to all abdominal lesions in World War I was approximately 22 per cent.<sup>10</sup> Associated injuries to other viscera in the order of their frequency are those of the colon, the stomach, the urinary bladder, the liver, the kidneys, the rectum and the spleen. Duodenal injuries are infrequent, constituting approximately 6 per cent of all small gut wounds. Injuries to the jejunum comprise about 23 per cent and those to the ileum approximately 71 per cent. The number of injuries produced by a single projectile may vary from one to thirty or more, but usually there are four to six. Figure 15

ciated with injuries of the small intestine; the symptoms vary with the amount of hemorrhage, the amount of spillage of intestinal contents, co-existing wounds of other viscera, and the time elapsed since injury. Neither the size nor the number of intestinal wounds bear a constant relationship to the signs or symptoms which accompany them. Figure 16 shows the absence of any significant relationship between mortality and the number of intestinal perforations in the author's series of cases. The importance of hemorrhage rather than the number of perforations in relation to mortality is shown by comparing Figure 16 with Figure 17.

*Wounds of the Colon.* Wounds of the colon constituted about 22 per cent of all intra-abdominal visceral injuries in the war of 1914 to 1918.<sup>10</sup> The colon is not uncommonly the only part of the alimentary tract hit. The comparatively small number of reported splenic flexure wounds is remarkable and it has been suggested that because of the difficulty of differentiating between the transverse and descending colons and the splenic flexure, some of the

injuries of the two former parts should have been described as lesions of the latter.

If a colon wound is small, there may be practically no early symptoms, whether the injury is extraperitoneal or intraperitoneal. This is especially true if the latter type of wound is uncomplicated and of such small size that there has been little bleeding or spillage of the usually semi-solid fecal material contained in the large intestine. It has been observed that the appearance of patients with large wounds of the colon often simulates that caused by severe hemorrhage.

*Wounds of the Rectum.* Injuries of the rectum are comparatively infrequent and constituted only 2.4 per cent of the lesions of abdominal viscera in World War I.<sup>10</sup> Associated lesions which may be encountered are those of the urinary bladder and the pelvic colon, or less frequently, injuries of the small bowel.

The rectal lesions vary in size from small perforations caused by minute projectiles or fragments of bone, to extensive lacerations. It is sometimes possible by digital examination to detect a perforation or a spicule of bone which projects into the lumen, while in other instances, blood on the gloved examining finger may be the only indication of rectal injury. Proctoscopic examination may reveal a perforation which is not detectable by an examining finger; and even if a perforation is not seen, the presence of blood as revealed by proctoscopic examination is indicative of injury to the rectum.

Wounds of the rectum are likely to be accompanied by fractures of the bony pelvis, spicules of which may wound the gut. As in the instance of the rest of the large intestine, there may be remarkably few symptoms associated with small wounds of the rectum. When a projectile or other object responsible for rectal trauma has entered through the hip, perineal, sacral, or gluteal regions, the existence of a rectal wound may be overlooked and it is sometimes not until there are evidences of general sepsis, pelvic

cellulitis, and even localized or diffuse peritonitis, that it is realized that the rectum has been injured.

*Injuries of the Gallbladder and Bile Ducts.* On account of their small size, injuries to these structures are relatively infrequent. Although spillage of bile following perforation or rupture of the gallbladder may result in considerable peritoneal irritation, as a rule the symptoms produced by these injuries are not characteristic, and it is only through a consideration of the probable wound track or by finding at operation that injuries of these structures are suspected or discovered. Bradycardia due to the outpouring of bile into the peritoneal cavity has been reported, but most patients with such injuries have a rapid pulse due to shock, and death usually occurs before there is slowing of the pulse.

*Injuries of the Mesentery and Omentum.* Injuries of the great omentum and the mesenteries are common. No characteristic symptoms are produced by injuries to these structures but hemorrhage due to injury of the vessels which course in them is often responsible for much of the shock which exists in patients with traumatic lesions of the abdomen, and frequently much of the blood found in the peritoneal cavity at the time of operation has come from injured vessels in the omentum or the various mesenteries.

*Wounds of the Liver.* Because of its large size, the liver is often injured, and wounds of this organ composed 13.3 per cent of all traumatic abdominal lesions in World War I.<sup>10</sup> Approximately three-quarters of the liver injuries were uncomplicated. Associated wounds to be expected are, in the order of their frequency, wounds of the colon, stomach and kidney. Figure 18 shows various types of liver injuries. The possibility of injury to the liver must be considered in all abdominothoracic wounds on the right side of the body. In addition to liver injuries caused by penetrating projectiles, serious live trauma frequently results from fractured ribs and from blunt

force. "Blast" injuries of the liver have also been reported.

Hemorrhage is always present following

if the patient survives the immediate loss of blood.

*Wounds of the Spleen.* Wounds of the

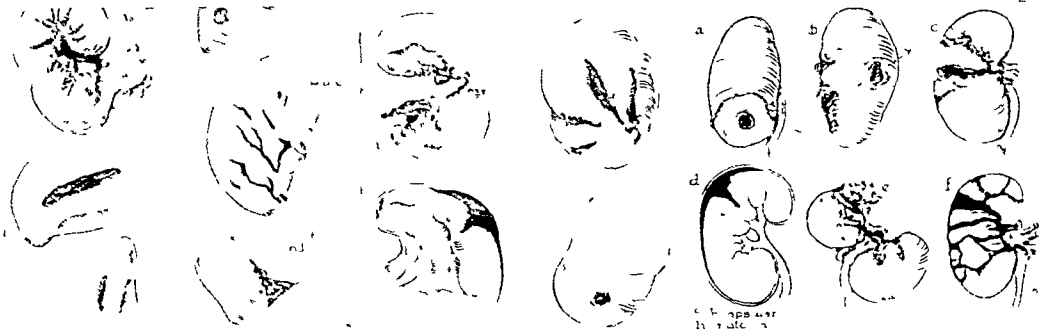


FIG. 18.

FIG. 19.

FIG. 20.

FIG. 18. Illustrations of various types of wounds of the liver. Excepting punctate wounds, indicated in (b), and furrowing or gutter wounds, indicated in (d), these different sorts of liver damage may be caused by blunt force as well as by projectiles or indriven objects.

FIG. 19. Illustrations of several types of injuries of the spleen. Excepting the type of wound shown in (d), such lesions may be produced by blunt force as well as by projectiles or other indriven objects. Splenectomy is the only satisfactory procedure when lesions such as those shown in (a) and (b) are found, and because of the danger of secondary hemorrhage, removal of the spleen should usually be done when a subcapsular hematoma such as is indicated in (c) is present, even though there is no bleeding from the spleen at the time of operation. When a small punctate wound is located near one of the poles of the spleen, as in (d), and there is no bleeding from the wound at the time of operation, it may be best not to perform splenectomy, especially if there are many injuries to other organs or if the patient is suffering from shock and hemorrhage.

FIG. 20. Illustration of various types of kidney injuries. For the smaller wounds, entirely conservative methods or suture yield the best results. Even when the extensive character of a kidney wound requires nephrectomy, it is often advisable to delay this procedure for several days or at least until the patient has recovered from shock.

liver wounds, and may vary from a slight ooze to a severe and rapidly fatal loss of blood. Symptoms and signs of peritoneal irritation result from the presence of blood, and sometimes from bile extravasated into the peritoneal cavity. If the amount of bleeding has been considerable, dullness may be detected in the flank, particularly on the right side. In the instance of cases seen two or three days after the injury, there is frequently slight jaundice; late jaundice indicates sepsis. Secondary hemorrhage from the liver may occur several days following injury. The occurrence of such delayed hemorrhage is commonly accompanied by pain, distention of the abdomen, rise of temperature, and acceleration of the pulse, associated with pallor, restlessness, and a rapid loss of strength. With these general symptoms, a localized swelling which may be indistinguishable from a secondary abscess usually develops

spleen are much less frequent than those of the liver, only forty-nine having been recorded as occurring in the American Expeditionary Forces in World War I.<sup>10</sup> Many of the cases with splenic wounds had complicating lesions, which usually involved the kidneys, stomach and colon. Figure 19 illustrates several types of injuries of the spleen.

Splenic injury must always be considered when there has been severe trauma on the left side of the chest or abdomen, whether due to blunt force or to a penetrating wound; and the possibility of perforation of the spleen by a fractured rib must be kept in mind.

The manifestations of injuries of the spleen are principally those of shock and hemorrhage, along with signs of peritoneal irritation caused by blood in the peritoneal cavity. An accumulation of blood in the left flank may occur in nonpenetrating



wounds of the abdomen with splenic injury, but damming up of blood in the left loin is not frequently detectable.

*Wounds of the Pancreas.* Cases with wounds of the pancreas reaching the hospital comprised about 0.2 per cent of all abdominal injuries in World War I.<sup>10</sup> In addition to wounds caused by projectiles, injury of the pancreas may be due to impingement of that organ against the vertebral column as the result of blunt pressure, such as that caused by being thrown against a motor vehicle steering wheel, or by being rolled over by a vehicle.

Pancreatic injuries do not cause characteristic early signs or symptoms. Even at the time of operation, the lesions are often obscured by a retroperitoneal hematoma. The first evidence of a wound of the pancreas may be that produced by the development of a pseudocyst several weeks or longer after the injury. Elevated levels of blood sugar, as well as increased amounts of blood lipase and diastase may be present for several days following pancreatic trauma.

*Wounds of the Adrenal Glands.* Due to their small size, the adrenal glands are seldom wounded. Even when damage to these glands occurs, recognition of the injuries is difficult or impossible because of the lack of distinctive symptoms, the position and smallness of the glands, and the frequent presence of an obscuring hematoma.

*Injuries of Large Blood Vessels.* Injuries to large abdominal blood vessels usually result in death before patients with such wounds can be transported to a hospital or to a military surgical unit. In addition to the immediate signs of severe shock and hemorrhage, as well as peritoneal irritation caused by hemorrhage into the peritoneal cavity, there may also be bleeding into the retroperitoneal spaces; and when this occurs, ileus is likely to be pronounced.

*Abdominothoracic Wounds.* These complicated wounds comprised 4.6 per cent of all the thoracic injuries brought to the evacuation hospitals of the American

Expeditionary Forces in World War I.<sup>10</sup> Other statistics,<sup>6</sup> based on observations in that war, show that the percentage of wounds involving both the chest and the abdomen was about 12 per cent. Abdominothoracic wounds are most often confined to one side, but both sides of the chest may be involved. Wounds low enough to involve both diaphragms are usually immediately fatal. In approximately one-third of the cases, a hollow abdominal organ is penetrated, and liver wounds are more common than are those of the spleen.

The characteristic manifestations of abdominothoracic wounds are sudden pain in the abdomen, dyspnea, hemothorax, abdominal rigidity and shock, which are dependent upon both hemorrhage and interference with normal respiration. Vomiting may occur, and there may also be localized tenderness. In cases with relatively small chest wounds, tension pneumothorax may cause more serious respiratory and circulatory disturbance than is ordinarily produced even by "blowing" wounds.

*Wounds of the Kidneys.* The kidneys may be injured either by blunt force or by penetrating missiles. These injuries constituted 6.3 per cent of all abdominal injuries in World War I, and one-half of the cases were uncomplicated.<sup>10</sup> Various types of kidney injuries are shown in Figure 20.

Hematuria is present in about 90 per cent of cases. It is usually detectable immediately after the injury and is, as a rule, proportionate to the extent of renal damage. Routine examination of the urine in penetrating or crushing wounds of the abdomen often reveals unsuspected urinary tract injuries. Although there may be grossly detectable blood in the urine, microscopic examination of the sediment from a centrifuged specimen may be necessary to reveal red blood cells. Hematuria may not be detectable for quite some time following kidney injury, either because of urinary suppression, the presence of blood clots or pieces of kidney tissue in the ureter, or severance of the ureter. Although hematuria may persist for a

relatively long time, it usually continues for only a few days.

Except when there is much associated hemorrhage, kidney injuries are attended with remarkably little shock. Pain is a common symptom and is often of a colicky nature, due to the presence of blood clots in the ureter. If there is distention of the pelvis or the true capsule of the kidney, however, pain is likely to be of a dull character. The pain may be generalized over the abdomen or it may radiate to the lumbar or sacral regions, or to the shoulder as well as to the hip. Nausea and vomiting are frequent symptoms, even when there has been no extravasation of blood or urine into the peritoneal cavity. Hemorrhage may occur from the loin wound or a hematoma may form in the flank. There may be localized rigidity of the lumbar muscles, or there may be considerable bleeding into the peritoneal cavity, so that tenderness, rigidity and dullness due to free blood in the abdomen may be detected.

Secondary hemorrhage is a fairly frequent and sometimes fatal late complication. It occurs most often during the second and third weeks after injury, usually in cases in which the urine is contaminated. Delayed hemorrhage may start afresh, or may manifest itself as an exacerbation of a persistent primary hemorrhage. Unlike primary hemorrhage, recurrent bleeding is often accompanied by clotting of the blood in the bladder.

Extravasation of urine into the peritoneal cavity, by adding to peritoneal irritation, increases the degree of rigidity and tenderness. External leakage of urine may occur when the pelvis of the kidney has been opened or when the ureter has been torn, but seldom is present when the injury involves the renal parenchyma alone. Especially in late cases, the escape of urine through a loin wound or the detection of a urinous odor furnishes evidence of a kidney injury.

X-ray examination is valuable in revealing the absence of a psoas muscle outline, flexion of the spine towards the affected

side, change in the size and contour of the kidney outline and limitation of renal mobility. Intravenous or retrograde pye-

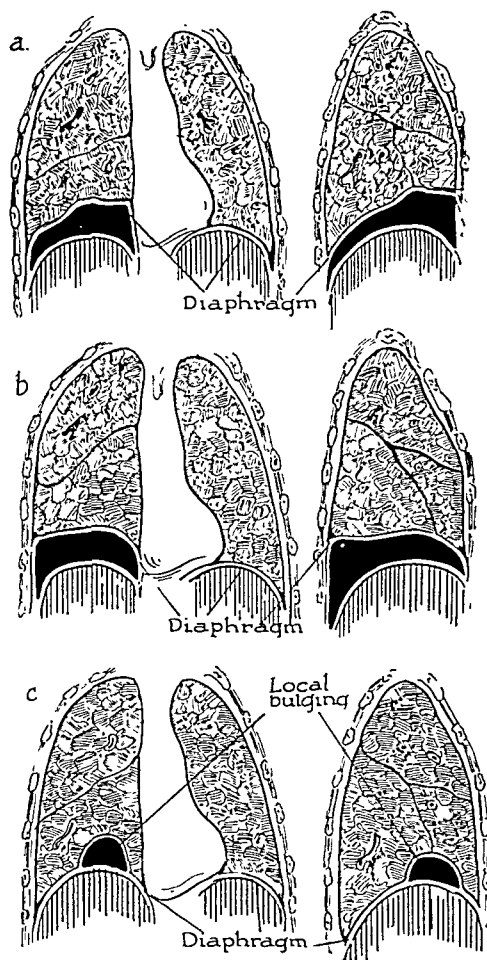


FIG. 21. Schematic representation of the x-ray findings in various types of subphrenic suppuration, and in abscess of the liver. (a) Shows the typical findings when subdiaphragmatic suppuration is secondary to liver abscess. There is obliteration of the cardiophrenic angle in the P. A. view and of the anterior costophrenic angle in the lateral view. (b) Shows the typical findings when subdiaphragmatic suppuration is due to peritonitis from various causes, including abscess of the liver. There is obliteration of the costophrenic (instead of the cardiophrenic) angle in the P. A. view and the posterior costophrenic (instead of the anterior costophrenic) angle in the lateral view. (c) Shows the typical findings in a liver abscess which has not ruptured into the subphrenic space.

lography or pyeloureterography may demonstrate the character and extent of a renal injury. Anterior displacement of the ureter

revealed by a lateral pyelogram, is evidence of a perinephritic accumulation of pus, blood or urine.

*Wounds of the Ureters.* Wounds of the ureters are rare, but preoperative recognition of their existence is important, for the introduction of a ureteral catheter usually facilitates location and repair of the injured ureter after the abdomen has been opened. Determination of the presence of a ureteral wound is often difficult. The appearance of hematuria may be delayed by spasm of the ureter, suppression of urine, severance of the ureter, obstruction by blood clots or by the existence of an anomaly.

*Wounds of the Bladder.* Wounds of the bladder comprised approximately 5 per cent of all abdominal lesions in World War I and one-half of the cases were uncomplicated.<sup>10</sup> Rupture of the bladder with extensive laceration due to a "bursting effect" is likely to occur if it is distended at the time of injury by a blunt force, but this same type of injury may also be produced when the full bladder is struck by a small projectile. The majority of bladder wounds were complicated by intestinal or bone injuries or both. A wound of the rectum was found in from 10 to 15 per cent of the cases, but injury of the prostate was comparatively rare. The small intestine was the organ most frequently wounded in conjunction with the bladder. In cases reaching the hospital, the entrance wound was most frequently located posteriorly, and a wound of exit usually was not present.

There may be hematuria following either penetrating or nonpenetrating bladder wounds, but micturition is sometimes impossible. Vomiting is a frequent symptom in extraperitoneal wounds. Discharge of urine through the entry wound is rather uncommon.

Bleeding into the bladder suggests an extraperitoneal lesion and with this type of injury there may be obvious swelling above Poupart's ligament, and at operation a large hematoma is sometimes found in the vicinity of the wound in the viscus.

An empty bladder, especially when associated with signs of peritoneal irritation, suggests the existence of intraperitoneal perforation with leakage of urine into the peritoneal cavity.

Cystoscopic examination is frequently impossible if there has been intraperitoneal perforation of the bladder. A cystogram may reveal the existence and extent of bladder wounds, especially the extraperitoneal ones associated with fractures of the bony pelvis. Extraperitoneal bladder lesions are often followed by pelvic cellulitis. In long-standing cases, bone necrosis, calculus formation and cystitis are frequent complications.

#### SELECTION OF CASES FOR OPERATION

The following criteria may be generally applied in determining the need for or the advisability of operative treatment in cases which have sustained abdominal trauma.

*Cases Definitely Requiring Operation.* When there is known or suspected abdominal visceral injury of recent occurrence without associated severe shock or extensive injuries to other parts, celiotomy should be performed as soon as possible.

*Hopeless Cases.* When the abdominal injury is of long duration, or when it is so extensive that satisfactory anatomical repair or functional restitution is obviously impossible, operation is not only of no avail but, in military practice, consumes time and materials which could be employed in caring for other casualty cases.

*Cases Not Requiring Operation.* In contrast to the cases in which the time factor or the extent of the injury make operation seem hopeless are those in which even exploration is unnecessary. Elective nonoperative management is most often applicable when no hollow visceral injuries are considered to exist, as when the injury is limited to the upper abdomen, especially to the liver area, and particularly if the injury has been inflicted by a small projectile or instrument.

When elective nonoperative treatment is contemplated, it is important to attempt

determination of whether or not hemorrhage has ceased, employing the methods already described. As shown by the observations of Kekwick, Marriott, Maycock, and Whitby,<sup>14</sup> if there are evidences of shock, differentiation must be made between primary shock from which improvement, including return of blood pressure to near normal, rapidly occurs following simple measures such as rest, the application of external heat, and the administration of morphine, and in which transfusion of even plasma may not be necessary; and secondary shock due to continued hemorrhage, in which improvement does not follow simple supportive treatment, and in which large transfusions of plasma or whole blood are required.

*Borderline Cases.* When twelve or more hours have elapsed since the injury, operative intervention usually only hastens death, regardless of the extent of the abdominal lesion. When wounds involve only the upper abdomen, however, operation even after a considerable lapse of time is sometimes advisable, not only because of continued hemorrhage from the liver or spleen, but because the frequent absence of hollow visceral perforations makes late operation relatively safe. Although injuries caused by small missiles may not require exploratory celiotomy, apparently trivial external lesions are often accompanied by extensive intraperitoneal wounds or gaping lacerated wounds of the hollow viscera.

#### CRITERIA FOR INTESTINAL RESECTION

Intestinal resection is to be avoided whenever possible, but several more or less absolute indications for removing a segment of the bowel must be recognized. Resection of a part of the intestine is most frequently necessary because of interference with its blood supply resulting from detachment of the mesentery, or because of division or thrombosis of large mesenteric blood vessels. If not at once evident, these conditions are usually manifested by absence of pulsation in mesenteric arteries

or by changes in the adjacent bowel, including deviation from normal color and absence of motility even after squeezing or warm applications. Resection may also be required when there is devitalization due to severe contusion or crushing of the intestine, or when there are multiple wounds in such close proximity that their individual closure would result in reduction of the size of the lumen or angulation of the bowel sufficient to cause obstruction.

#### POSTOPERATIVE OR LATE COMPLICATIONS

In addition to early complicating conditions, such as shock and hemorrhage, which occur simultaneously with or immediately following injury, late complications must be anticipated and recognized promptly.

*Shock and Hemorrhage.* Incomplete recovery from an initial state of shock, delayed shock, or recurrent shock following operation, is frequently observed following traumatic lesions of the abdomen. Secondary shock may be due to continuance of bleeding from kidney, liver or other wounds, or may result from incomplete hemostasis at the time of operation. Massive secondary hemorrhage and severe shock may, in other instances, be due to the rupture of a subcapsular hematoma, particularly of the spleen or liver, after several days or even weeks have elapsed following the injury. Details of the evidences of secondary bleeding from the liver have already been discussed in conjunction with the special consideration of liver injuries.

*Ileus and Peritonitis.* Some degree of both adynamic ileus and peritonitis follows many abdominal traumas, either as a result of exposure, manipulation, or contamination of the peritoneum and the peritoneal contents. Ileus may be due to the presence of a retroperitoneal hematoma, while in other instances, both ileus and peritoneal irritation may be caused by the presence of blood, bile, or urine in the peritoneal cavity. Mechanical intestinal obstruction may complicate cases of abdominal trauma in which there has been associated peritonitis, or when operative

repair of gastrointestinal injuries has resulted in either narrowing of the lumen or angulation of the intestine. Discontinuance

for determining blood specific gravity, combined with determinations of mean corpuscular volume by the hematocrit.



FIGS. 22A AND B. A traumatic pseudocyst of the pancreas is outlined by the displacements and filling defects of the stomach and transverse colon in these anteroposterior and oblique x-ray projections following ingestion of barium emulsion by a patient whose pancreatic injury was incurred in an automobile accident.

of the practice of performing enterostomy and of introducing drains into the peritoneal cavity, has eliminated these causes of secondary intestinal obstruction.

*Thoracic Complications.* Pulmonary complications, notably lobular or massive pulmonary atelectasis and pneumonitis, must be anticipated and recognized early by means of physical or roentgenologic examination.

*Dehydration.* Dehydration or insufficient fluid intake can be detected by measurement of the urinary output, dryness and coating of the tongue, or by such laboratory methods as red blood cell counts, hematocrit determinations, or blood specific gravity studies.

*Hypoproteinemia.* Lowering of the plasma proteins to levels where wound healing and convalescence in general is retarded can be quickly and simply recognized by means of the falling drop method

*Wound Infection.* Recognition of wound infections due to common pyogenic organisms, gas bacilli and other anaerobic or micro-aerophilic bacteria including the micro-aerophilic hemolytic streptococcus, can often be made with fair accuracy by inspection or palpation of the wound, by the appearance of the exudate, or by the associated odor, which latter may be extremely foul when anaerobic infection exists. Retroperitoneal infection may give few evidences of its existence other than profound toxemia. Bacteriologic studies including examination of cultures and direct smears made from the wound edges or wound exudate can furnish additional data which permit employment of the most appropriate therapeutic agents, such as specific sera or vaccines, sulfonamide drugs, oxidizing substances such as zinc peroxide, or such chemotherapeutic preparations as gramicidin and penicillin.

*Residual Abscess.* Continued elevation of temperature or the occurrence of chills, when not accounted for by wound infection, suggests the presence of a residual abscess. An abscess in the rectovesical space may also be accompanied by diarrhea, loss of tone of the anal sphincter, and a pelvic mass detectable by rectal examination. Subphrenic abscess formation may be revealed by the presence of tenderness when pressure is made over the lower ribs, and the existence of an abscess in this region may be confirmed by the roentgenologic findings described by Granger<sup>15</sup> and shown in Figure 21. Subhepatic, perirenal, iliac fossa and other residual intraperitoneal abscesses are usually detectable by the presence of localized tenderness and rigidity, or even a palpable mass. X-ray examination may reveal a retained foreign body.

*Rupture of Intramural Abscess and Delayed Rupture of the Intestine.* Rupture of an intramural abscess may occur into the peritoneal cavity, and delayed rupture of the intestine may follow the stripping loose of its outer layers at the time of injury, as well as infarction resulting from tearing away or other injury of blood vessels in the mesentery. The former complication rarely occurs before the sixth or seventh day following injury or operation and usually causes immediate severe prostration and profound toxemia which is ordinarily soon followed by death. Delayed rupture of the intestine, although usually more insidious in its manifestations as a result of walling off by adjacent viscera, is no less fatal than is intraperitoneal rupture of an abdominal wall abscess. Ischemic necrosis and rupture of the intestine may occur as early as the third day following injury or operation, but is ordinarily delayed for six or seven days, when it may be the first definite evidence that severe visceral damage was done at the time of an abdominal injury.

*Persistent Draining Sinuses.* The development and persistence of a sinus tract suggests the presence of a retained missile

or other foreign body, for which x-ray examination or even direct exploration may be necessary.

*Traumatic Pseudocyst of the Pancreas.* This late complication of abdominal trauma may be expected following severe blunt injuries to the upper abdomen, or definitely known pancreatic penetration, and is detectable by palpation of a mass in the upper abdomen, or by the roentgenologic demonstration of displacement of the stomach and transverse colon. (Fig. 22.)

*Toxic Manifestations of Sulfonamide Drugs.* The frequent necessity of administering the various sulfonamide drugs has added the toxic effects of these agents to the possible late complications in traumatic lesions of the abdomen. Hyperpyrexia, nausea, vomiting, diarrhea, jaundice and dermatitis are common clinical evidences of toxicity due to sulfonamide therapy. Undesirably high blood concentrations of these drugs will be revealed by the laboratory studies which should govern their administration.

#### SUMMARY

1. Diagnosis in traumatic lesions of the abdomen includes investigation in respect to shock, hemorrhage and other associated conditions, as well as determinations of the location and extent of abdominal injury.

2. Even in obscure cases with either penetrating wounds, or visceral injuries caused by blunt force, diagnosis is usually possible before shock and hemorrhage, or extravasation of gastrointestinal contents have been fatally prolonged or extensive.

3. The clinical manifestations as well as the findings obtained by clinical laboratory, x-ray and endoscopic methods of study, which permit early diagnosis and serve as a guide to therapy are presented.

4. The indications for and methods of exploring the abdominal wall wound as well as the peritoneal cavity are detailed.

5. Criteria for the selection of cases requiring operative treatment, and for the timing of surgical intervention are given.

6. The incidence and character of lesions as revealed at the time of operation is reviewed.

7. Methods of determining the presence and extent of hidden lesions at the time of operation are discussed.

8. The complications which frequently follow abdominal injuries are considered in respect to the importance of their early recognition.

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# TRAUMATIC AND INFECTIOUS TENOSYNOVITIS

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A SYSTEMIC disease that causes the hospitalization of 7 to 111 per hundred thousand admissions, depending on the type of hospital one investigates,<sup>1</sup> would hardly seem worthy of extensive discussion. Yet because the larger number are not hospitalized and because of the severe disability that flows from these affections, and because of the large percentage of errors in diagnosis, we believe that it is worthy of a careful review. Seven facts of tendon anatomy should be remembered:

*First:* Most tendons do not have a sheath but operate through primitive areolar tissue.<sup>2</sup> Here arises most mistakes in diagnosis. One may have tenosynovitis of only certain tendons.

*Second:* Wherever tendons began to operate under gravitational pressure beneath retentive ligaments mucous sheaths were developed<sup>3</sup> to (a) facilitate motion, (b) reduce wear, and (c) promote repair. This was true in the weightbearing shoulder, the hands and the feet. Specifically, tendon sheaths occur around the following tendons:<sup>4</sup> (Fig. 1.)

1. Shoulder—the long head of the biceps

2. Hand and wrist

(a) Flexor surface

1'. Communal sheath for the carpal portion of the deep and superficial finger flexors 2-4, and the entire tendon of the fifth finger

2'. The long flexor of the thumb

3'. Digital sheaths for the tendons of fingers 2-4

(b) Extensor surface

1'. Carpal sheath for each wrist extensor

2'. Communal sheath for the carpal portion of the finger extensors 2-4

3'. Extensor of the fifth finger

4'. Long extensor of the thumb

5'. Communal sheath for the long abductor and short extensor of the thumb

3. Foot

(a) Dorsal surface

1'. Communal sheath for the extensors of the toes 2-5, and the peroneus tertius

2'. Extensors of the great toe

3'. Anterior tibial

(b) Mesial surface

1'. Posterior tibial

2'. Long toe flexors

3'. Long flexor of the great toe

(c) Plantar surface

1'. Sheath for the digital portion of each toe's flexors

2'. Plantar portion of the peroneus longus

(d) Lateral surface

1'. Communal sheath for the peroneus longus and brevis

In man the shoulder and wrist have long since ceased to be under major gravitational strain but the primitive mechanism remains. One, therefore, cannot properly speak of tenosynovitis of the tendo-achilles or of the hamstrings or of the supraspinatus.

*Third:* It is generally believed<sup>2</sup> that at first simple bursa developed at the site of friction, and as the force continued bony grooves developed and the tendon became almost completely surrounded by the bursa leaving a mesotendon between the visceral and parietal portions of the bursa on the side with minimal pressure. Nerves and vessels passed through the mesotendon. The embryological work of Shield,<sup>3</sup> however, shows that the synovial covering of the tendon is a "specific functional characteristic of the mesenchymal cells in-



volved and is not merely the result of a collection of fluids in the tissue." He has also shown that the development begins in

as modified cartilage cells; by Kingsley<sup>6</sup> as epithelial; by Piersol<sup>7</sup> as endothelial. Morton,<sup>8</sup> it seems to me, has most accu-

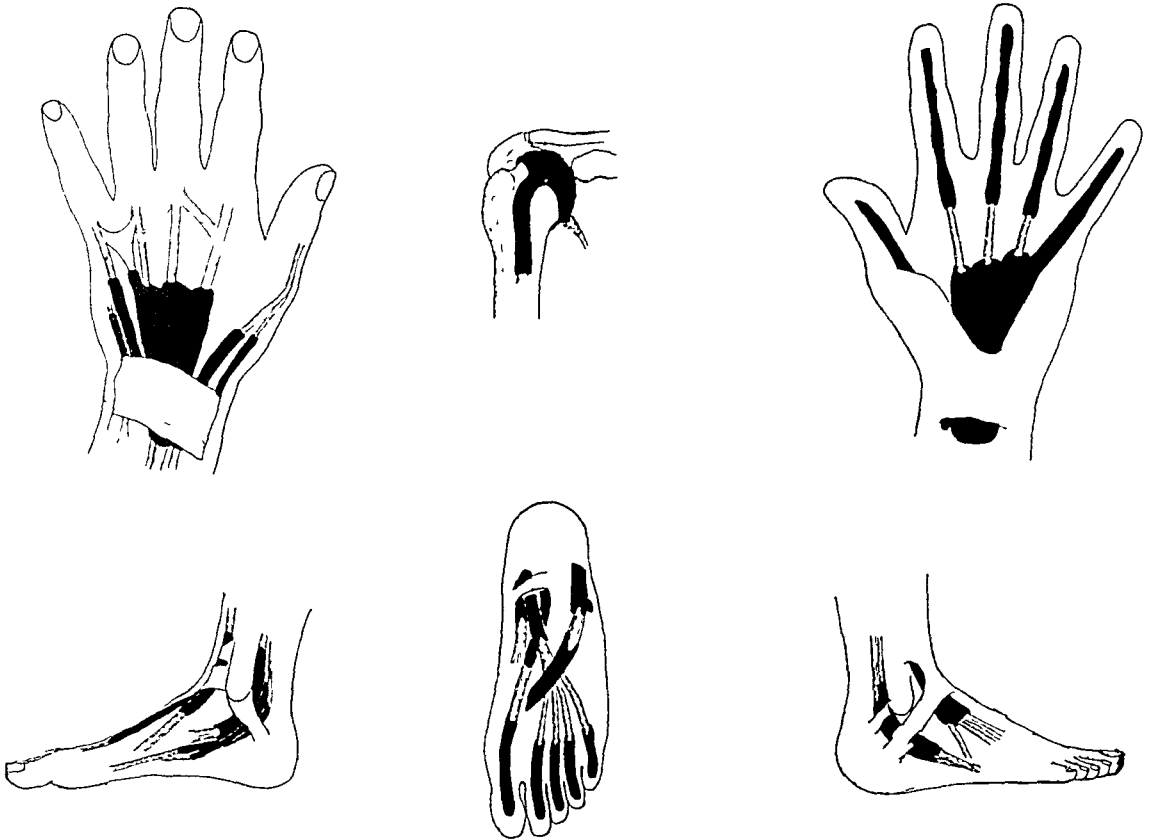


FIG. 1. Sites of tendon sheaths.

the metatarsal area in the foot and extends proximally, but that even in large embryos the proximal end of the sheath is not completely walled off from the tissue spaces.

*Fourth:* In order to give the desired freedom of motion to the tendon, the sheath extends beyond the retentive ligament for about an inch.<sup>2</sup>

*Fifth:* When two or more tendons closely parallel one another, a communal sheath or communicating sheaths frequently developed. At the shoulder the synovial sheath merges with the synovial lining of the joint.<sup>2,4</sup>

*Sixth:* As the range of motion increases, the mesotendon becomes more tenuous and in some cases disappears entirely, leaving only some villous remnants.<sup>2</sup>

*Seventh:* The synovial lining of joints, bursa, and tendon sheaths are identical histologically and is described by Keith<sup>3</sup>

rately described the tissue when he states, "The synovial cell is a modified mesenchymal cell with multipotential qualities." We may, therefore, anticipate similar diseases affecting joints, bursa and tendon sheaths.

Tendon sheaths are affected by (1) trauma, (2) infections, (3) neoplasms and (4) disturbances of metabolism.

*Trauma* is probably the most frequent cause of tendon disability and usually appears in the more exposed tendons, viz., the shoulder, the abductor-extensor sheath of the thumb and the peroneal tendons. The injury may be single or multiple, severe or slight. The shoulder usually bears the brunt of the single severe accident while the thumb is usually affected by many small injuries.

*Tenosynovitis of the long head of the biceps* usually follows falls, or strain of the shoulder, particularly is it likely to follow

a Colles' fracture. It is manifest by pain in the bicipital groove and difficulty in extending, abducting and rotating the

of these creatures became fixed in pronation or nearly so in order to bring the fore-foot on the ground. A cat has about thirty

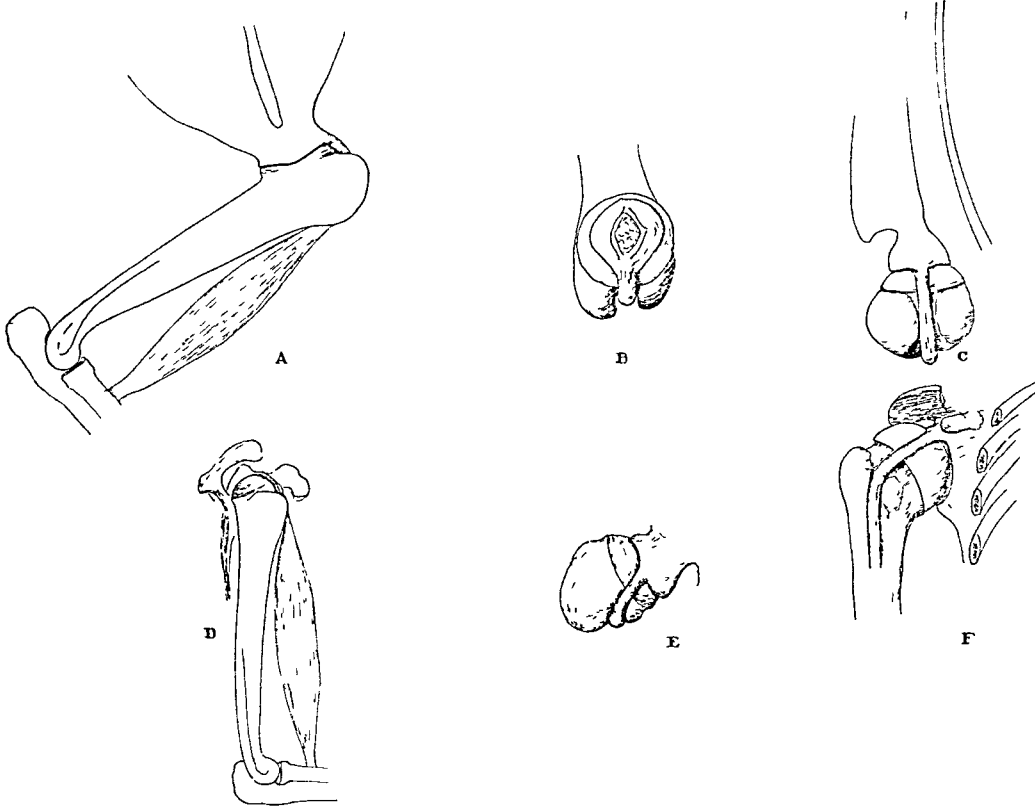


FIG. 2. Evolution of shoulder and biceps tendon-schematic. A-C, quadrupedal; D-F, human.

shoulder. Meyer's<sup>10</sup> careful work has shown the effect of wear and tear at this point, while Abbott<sup>11</sup> has concerned himself with dislocations of the tendon. The common cause of all these troubles is found in the evolution of the shoulder.

With the rise of mammals the legs were drawn close to the body for use in the sagittal plane and quadrupedal posture became habitual rather than occasional. In the quadruped the glenoid faces downward onto the upturned face of the humeral head. (Fig. 2A-C.) The supraglenoid tubercle in many projects beyond the articular surface. The spinati and the subscapular muscles are the chief flexors of the humerus and the development of the tuberosities vary in accordance with the use and weight of the owner. The long head of the biceps tendon runs directly from the supraglenoid tubercle into the intertubercular groove without contacting the articular surface. The forearm of many

degrees of supination, a dog only a trace. Contraction of the long head of the biceps could, therefore, have only two functions: (1) flexion of the elbow and (2) active support of the humeral head, preventing headward dislocation.

With the rise of the large brachiating primates, including man, changes occurred. The deep and narrow chest became broad and shallow, bringing the scapulas from a lateral to a dorsal position. In their erect position the humerus still parallels the torso but the axis of the articular surface has rotated in respect to the intercondylar axis so that (1) the subscapularis has lost most of its postural and flexor activity, becoming a mere internal rotator of the humerus with a resultant diminution of the lesser tuberosity and (2) the bicipital tendon lies obliquely across the humeral head, causing it to turn sharply around the now recessive lesser tuberosity. Each contraction of the long head of the biceps

would, therefore, tend to draw the tendon against the lesser tuberosity and retentive ligament, causing wear and tear which might eventuate in a fraying or a dislocation of the tendon. Its exposed position would tend to subject it to a crushing injury between the head of the humerus and the acromion. Any motion that would tend to displace the head of the humerus forward would throw additional strain of the bicipital tendon. Such accidents might cause sufficient damage to the tendon producing reparative actions and adhesions causing the characteristic signs of tenosynovitis of this tendon.

*Tenosynovitis of the abductor and short extensor of the thumb* might almost be classified as a female disease as about 80 per cent of the cases<sup>12</sup> occur in women near the menopause. In various ways they turn their hands into flexion and ulnar deviation as in wringing clothes, throwing the typewriter carriage back into the starting position, etc. Wearing a heavy bracelet would also predispose to this condition. It is reported as an acute temporary condition in males returning to work as carpenters, and gardeners after long lay-offs. These slight injuries result in an inflammation of the tendon sheath with early crepitation and subsequently in a scarification of the sheath which gradually constricts the tendon and may cause the appearance of a nodule within the tendon itself. As the tendon is moved either actively or passively, the tendon slips with difficulty through the constriction and a definite snap may occur. At times the tendinous lump may become locked on one side of the constriction. As the condition is frequently occupational in character, it is severely disabling. In one patient upon whom I operated the nodule had white areas that reminded one of the calcareous deposits found at the shoulder and other points. This probably represents an added metabolic disturbance.

Similar conditions, either congenital or acquired, may occur in one or more finger flexors in the region of the metacarpophalangeal joint.

*Peroneal tendons* are subject to injury when the ankle is sprained by inversion or they may be irritated by spurs from the fibula following sprains. Such an injury, of course, may affect other parts of the foot as well. If the irritation continues, a spasm of the peroneal muscles may be set up which holds the foot in painful eversion. It may be impossible to tell whether the causative factor is a tendovaginitis or arthritis but, fortunately, the treatment is identical.

#### TREATMENT OF TRAUMATIC TENOSYNOVITIS

The object of treatment in any acute injury should be (1) to permit healing and (2) to avoid disability. Obviously, rest in a position free from strain or contracture is the best method of aiding healing, but rest too long continued is likely to result in adhesive scar formation that will be quite disabling. An injured part, therefore, should be put through the maximal range of motion compatible with retention of the injured parts in close apposition. This does not mean pump handling the part several times a day or once a week, but it means at least moving the part once a day in order to prevent the formation of heavy adhesions.

On the other hand, many of the cases that come to the orthopedic surgeon show that because of pain the part has been kept in one position until the part has "frozen." In the well developed chronic cases of tenosynovitis, two general courses of treatment are open to us depending on the type of lesion.

In tenosynovitis of the shoulder and peroneal tenosynovitis, the demands are such that the part be remobilized by breaking down the adhesions that exist. To accomplish this, the part has to be put through a complete range of motion paying especial attention to the position of the involved tendon.

At the shoulder, the long head of the biceps should be placed in maximum tension with the greatest possible protection that the tuberosities can afford when the part is moved. The first move, therefore,

should be to abduct and rotate the humerus outward about 45 degrees, bringing the tendon directly over the top of the humeral head, obliterating the angle at the lesser tuberosity. The forearm should be kept extended and fully pronated. Maintaining this position, the arm should be carried into full extension and then flexion. The elbow may now be flexed, the forearm supinated and the hand placed between the shoulders in both flexion and extension. Disregarding the biceps tendon, the shoulder may now be internally rotated and flexed and extended through its maximal range in the sagittal plane. Likewise, it should be abducted. Finally, the humerus should be pulled to distract it from the scapula. The hand should then be placed behind the head or neck and the patient should be allowed to awaken in this position as proof of the range of motion.

In frail individuals the arm may be placed in traction in the line of deformity, changing the angle of pull to full abduction as the shoulder loosens up.

The peroneal tendon may be manipulated by maximal inversion of the foot in both flexion and extension. The heel should be raised one-fourth inch along the medial border to prevent the old position from recurring while the patient is standing or walking.

Whatever tendon we are manipulating, it is essential that the individual continue the restored motions of his arm or foot to prevent the reformation of adhesions.

At the crepitating stage the thumb and wrist should be put at rest in a cast, while in a stenosed tenosynovitis of the thumb the sheath must be split or removed in order to give a free range of motion; and if the tendinous nodule is large, it should be excised.

*Infectious tenosynovitis* is most likely to occur on the palmar surface of exposed hands rather than in the protected feet. Usually it is secondary to wounds but it may be metastatic from remote foci as the urethra, teeth or tonsils and by extension from contiguous bones and joints. Owing to the formation of the tendon sheaths, the

infections arising in the little finger and thumb are the dreaded ones because of their direct extension to the carpal area with the possibility of involving all the finger tendons. Infections of the three central fingers are not likely to extend beyond the distal crease of the palm. Infections, too, are serious, not only on account of the plastic exudate that binds them down, but because they are very likely to interfere with the blood supply of the tendons with a resultant interminable necrosis.

Clinically, three major types of infections occur: (1) staphylococcic and streptococcic, (2) gonococcic and (3) tuberculosis.

Streptococcic and staphylococcic tenosynovitis is a worker's disease arising shortly after the receipt of a finger wound. Severe local and general symptoms quickly develop. The sheath and its communicants swell and acute throbbing pain appears with generalized swelling of the hand. Tenderness is exquisite. Pus may be secured early and permanent disability is minimized by prompt treatment. Streptococcic infections are likely to show lymphangitic red streaks up the forearm, a danger signal of the first magnitude.

Gonococcal infections arise metastatically in any tenovaginal sheath of the hot and foolish. The local and constitutional symptoms belie the duration of the infection by their mildness. Aspiration yields a characteristic greasy, gray translucent pus which should be smeared and cultured to confirm the diagnosis.

Tuberculosis is usually secondary to contiguous or remote foci. An insidious onset of tenovaginal swelling in young adults may be the only sign. Tuberculosis elsewhere should make the diagnostician alert. This condition may also be confused with some tumor formations, owing to its tendency to produce small translucent cartilaginous "rice bodies" which may be felt, imparting a peculiar sensation to the examining hand when the part is moved.

#### TREATMENT OF INFECTIOUS TENOSYNOVITIS

Treatment of infectious tenosynovitis varies with the type of infection. In the

acute staphylococcic type when pus is present drainage is imperative; while in either type, but especially the streptococcic, if lymphangitis is present, no surgery should be done until the lymphangitis is cleared up by hot packs and the use of specific drugs. To do radical surgery in the face of the red flag of lymphangitis is likely to hasten the demise of an otherwise useful citizen. When the lymphangitis has subsided leaving a collection of pus or when pus exists without lymphangitis, the indication is for surgery of both a radical and exact nature. Kanavel<sup>14</sup> pointed out in his monograph the value of certain incisions which (1) kept the scars off bearing surfaces and (2) preserved the retentive ligaments which act as pulleys for the tendons so that the ligaments bend normally and not with a tendinous band extending chord-like between the joints on either side of the one operated upon, resembling the chord of a Dupuytren's contracture. The value of the pulleys cannot be over-emphasized. To this end the incision in the fingers should be located posterolaterally along the sides of the phalanges but not crossing the joints. If the thumb or little finger is involved, the sheath may be opened by an incision along the mesial border of the respective eminences, being very careful to preserve the nerve supply of the eminence. If the carpal sheath is involved the incision should be on either side of the wrist just on the palmar surface of the bone. (3) In draining the sheath no foreign body should bear against the tendon, but the sheath should be kept open by vaseline packs. (4) The use of hot antiseptic baths or saline baths tend to reduce the pus and promote drainage. (5) The pus should be examined, the organism identified and the proper sulfonamide drug should be adequately administered. (6) For comfort's sake the hand should be splinted in nearly full extension to prevent contractures and (7) the hand should be elevated.

Gonorrheal tenosynovitis should be treated by the use of proper drugs, splint

and heat, but under no circumstances should the sheath be opened and drainage established.

Tuberculous tenosynovitis demands a complete, careful dissection of the diseased area which may necessitate reconstructive measures later. The removal of the finger flexors might call for a fusion of the wrist and muscle transplants to the remains of the flexor tendons. Potts<sup>13</sup> advises x-ray treatments twenty-four hours in advance of surgery, and again a week after surgery he believes that x-ray treatments should begin and be repeated every two weeks. Personally, I have had no experience with this physical adjuvant. In the presence of severely destructive lesions and old sinuses one should consider amputation as the shortest means of rehabilitation.

#### SUMMARY

Tenosynovitis of two types has been discussed and the common traumatic and the rarer infections have been described. Both are severely disabling, require exact diagnosis and prompt, proper care for their alleviation.

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# TRAUMATIC VASOSPASM AND ITS RELATIONSHIP TO WOUNDS OF THE LOWER EXTREMITIES\*

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THE casualties of modern war as well as the increased number of industrial accidents in defense-booming mills and mines have stimulated renewed interest in the problem of wound healing.

Gas gangrene, particularly in wounds of the lower extremities, is one of the most dreaded complications of compound fractures. The struggle for its prevention, as well as for the control of other pyogenic infections of the soft tissues, of osteomyelitis and of delayed and nonunion, has long called forth the best efforts of the finest medical minds. It is, therefore, with some reluctance, and only in view of existing world conditions, that I present the following conclusions at this time. Should this seem a premature report, I offer in mitigation the urgency of the moment and the hope that those interested in this field may receive it with sympathy and give it further study.

It is my belief that lumbar sympathetic nerve block has a definite place in the routine treatment of compound fractures and severe wounds involving the lower extremities.

This conclusion is based on the reasonable supposition that any force sufficient to damage severely the tissues or to fracture heavy bones is sufficient to disturb the blood vessels, directly or indirectly, by damaging the sympathetic nervous system and thus producing arterial spasms of varying degrees. Thus, I am convinced that many patients treated in the emergency rooms of large hospitals for compound fractures and other extensive wound

damage to the extremities also suffer *some degree* of traumatic vasospasm. Because of the importance of the visible injury, which may easily monopolize the attention of the physician at the time, such vasospasms have in the past gone unrecognized.

My interest in the problem of wound infection in traumatic cases has extended over a number of years. From 1927 to 1936 at the Mercy Hospital a great number of such cases came to my attention; the majority were men who worked in coal mines. The incidence of gas gangrene among these injured miners was high, despite careful and studied attempts to prevent infection. More than fifty such cases came to my attention in that period. Our conclusion then was that best results could be obtained by early treatment of the wounds, careful débridement, immediate fixation of fragments and immobilization of the part to prevent further destruction of muscle by sharp edges of the fractured bones. It was found that if the wounds were left open and packed loosely with gauze, infection was less likely to occur, and that when it did, it was less severe.

Yet, despite these steps and an alertness to improve the technic whenever and wherever possible, it was obvious that the great problem of preventing infection was unsolved. The incidence of infection was still far too high for complacency.

Twelve years of work in my clinic for vascular diseases of the lower extremities has made me acutely conscious of the various circulatory problems which confront the surgeon. It has been my experi-

\* From the Surgical Service and The Vascular Clinic, Mercy Hospital, Pittsburgh, Pennsylvania. Read in part before the annual meeting of the Surgeons Club, New Orleans, Louisiana, April 14, 1941.

ence to see many severe cases of vascular spasm—several the result of direct trauma to large vessels.

It was not, however, until one day when called upon to treat a patient suffering from a compound fracture of the tibia and fibula in a hospital of a nearby town that the importance of traumatic vasospasm in relation to traumatic wounds of the legs was clearly brought home to me.

CASE I. I first saw the patient, a young adult, several hours after the accident. He lay upon the operating table of the emergency room, suffering from a compound fracture of the tibia and fibula, with a large gaping wound extending from the knee to the ankle. All muscles were evulsed and many structures exposed. The bones protruded from the wound. The skin was pale and the tissues had a cold and clammy feel. The femoral pulsations were present but faint. The popliteal pulsations were absent. There was no dorsalis pedis pulse. The general condition of the patient was fair; the degree of shock was slight.

After an intravenous injection of glucose and saline, the patient was removed to the operating room. Sodium pentathol anesthesia was administered. After careful débridement of the destroyed tissue, the fractured bones were approximated and plated. The wound was packed and loosely closed. Lateral plaster splints were applied to the leg.

The patient was then turned over, face down, and a paravertebral lumbar sympathetic block was performed with 20 cc. of 2 per cent novocaine. He was then sent to bed.

Within about ten minutes, although the exact time was not noted, the toes were quite pink, and the femoral pulse was much more vigorous. (The popliteal pulse could not be felt because of the plaster splints.)

The patient made an entirely uneventful recovery. The fracture united in the normal length of time and the wound healed without complication.

In this case the traumatic vasospasm was obvious. However, the relationship of the spasm to the wound, opened up to me a new line of thought.

Was it not reasonable to suppose that in all serious wounds of the lower extremities

there is some degree of spasm, which, by diminishing the blood supply to the part, gives the infecting organisms time to establish themselves firmly? Such unrecognized vasospasms might be the reason why compound fractures of the extremities are so likely to become infected. As Dr. Griffith<sup>1</sup> points out, there is no better therapeutic "chemistry" to be introduced into a wound than that which nature produces from clean muscles and an adequate blood supply. Any procedure, within the realm of safety, which would increase the blood supply to the injured part would be justified.

By blocking the sympathetic ganglia with novocaine, the vasomotor reflex would be broken, the contraction of the artery released and the flow of blood to the part greatly accelerated.

The technic of the lumbar sympathetic block is comparatively simple, and if done carefully can cause no possible damage to the patient. Ochsner and DeBailey<sup>2</sup> perform it regularly on out-patients when they wish to differentiate between arterial deficiencies due to organic disease and those due to vasospastic states. They point out that chemical block of the regional sympathetic ganglia is a conservative procedure in peripheral vascular disease because of its efficacy, its simplicity and its facility of performance.

I was so stimulated by the results of the nerve block in the case described that when, less than a month later, a patient with soil-contaminated compound fractures of both legs was admitted to my service I decided again to use the nerve block.

CASE II. The danger of infection in this case was clear since the patient, a boy seventeen years old, employed in a slaughter-house, had been run over by a truck in the slaughter-house yard. Not only had his clothing been contaminated by the feces of the animals with which he worked, but portions of it had been ground into the wounds by the wheels of the truck.

The patient's left extremity suffered an extensive wound exposing large groups of

muscle. The fracture was compound comminuted and a fragment of bone had been lost. A compound fracture of the right leg was exposed by a wound less severe than the left. Both the limbs, as in the first case, were cold and clammy out of all proportion to the mild degree of shock which existed. The pulsations of the femoral vessels were weak and the popliteals and dorsalis pedes were not palpable.

This lad was taken to the operating room immediately. Both wounds were carefully débrided and sulfathiazole was powdered over the extensive wound on the left leg, while none was used upon the wound of the right leg. The bones of the left leg were approximated and a Sherman bone plate used to fix them in position. The fractured portions of the bone in the right leg were approximated but no plate applied. Both wounds were lightly packed with gauze and the wound edges loosely approximated. Lateral plaster splints were applied to both legs and in this instance the application of the splints was followed by a bilateral lumbar sympathetic block.

This boy made an uneventful recovery. The wounds healed without any evidence of infection of soft tissue or bone. The boy left the hospital in 120 days and five months afterward was able to walk without the aid of a crutch or cane.

CASE III. A healthy young adult had fallen thirty feet from a crane he was operating in a steel mill. He suffered an extensive compound fracture involving the ankle joint. He was treated in precisely the same manner as in Case II namely, a careful débridement within an hour after the accident, reduction of the fracture, loose closure of the wound, packing with dry gauze, application of plaster splints and a lumbar sympathetic block. This patient also made an uneventful recovery without infection.

Several other compound fracture cases after these, although showing no marked evidence of arterial spasm, seemed to benefit by the paravertebral sympathetic block of the ganglia.

It is a well recognized fact, as noted by both Kroh<sup>3</sup> and Homans,<sup>4</sup> that traumatic vasospasm is a definite entity. This vasospasm can exist, they point out, because of direct trauma to the vessels, or in many instances, as the result of disturbances to

the local vasomotor nerves which influence the functioning of these vessels. Perhaps the cause makes little difference, since, in any case, a nervous mechanism in close relation to the vessel seems to have been set in motion.

Homans<sup>4</sup> also points out that traumatic arterial spasm may be brought on by a variety of injuries, including fractures, blows, bullet wounds and stabs; and that although there is sometimes evidence of direct trauma to the arterial wall, almost as often the artery itself seems never to have been touched.

Cases of acute arterial spasm resulting from fractures have been described by Montgomery and Ireland<sup>5</sup> and in these it was impossible to state whether the spasm was induced by direct trauma to the artery or whether by injury to the artery's sympathetic nerve supply.

It seems reasonable to contend that any force sufficient to damage severely the tissues or to fracture heavy bones is sufficient to disturb the blood vessels, directly or indirectly, by damaging the sympathetic nervous system which controls the size of the lumen and thus to produce arterial spasms of varying degrees, diminishing the blood supply at the very time it is needed for healing of the wound.

Spasms due to trauma last for hours, even for days. It is true that in a limb uncomplicated by an open lesion or a fracture, there is as a rule, no complicated after-effects from a traumatic vasospasm, although I have seen cases in which several toes became gangrenous and were lost as a result of this type of injury.

In compound fractures of the lower extremities, it appears that the vasospasm is a transitory thing and usually passes off itself in due time. However, the period of time necessary for nature automatically to release this spasm gives the infecting organisms time to establish themselves firmly. The generalized ischemia set up by the spasm promotes an excellent medium for bacterial growth. The nerve block



shortens the dangerous interim of diminished blood supply by releasing a rich flow of blood to the injured part at this critical time.

Brown<sup>6</sup> has stated that wounds about the face involving bones that do not communicate with the oral cavity rarely become infected. He attributes this rapid healing of bone in this region to the excellent blood supply. Compound fractures involving the arm, while they may become infected, do not present the same high incidence of infection as those of the legs; and again this may be attributed to a better blood supply in that region.

It seems to me, after observing and treating many compound fractures of the extremities, that release of the vasoconstrictor impulses of the accompanying but usually unrecognized vasospasm may mean the difference between the successful healing of wound and infection. I believe that many cases of osteomyelitis, gas gangrene and other pyogenic infections of the soft tissues and possibly also of delayed and nonunion, could have been prevented had we recognized the importance of traumatic vasospasm in its varying degrees of intensity in the extremities of those treated for serious wounds and compound fractures. Although the number of cases in this report is not great, the results are so gratifying as to indicate that the lumbar sympathetic nerve block has a definite place in effective therapeusis in compound fracture and severe wounds of the lower extremities.

#### TREATMENT

I suggest that adequate treatment of compound fractures of the lower extremities is as follows:

1. Early primary attention and all possible speed in getting the patient to the hospital. As Kennedy<sup>7</sup> states, "the length of time between the occurrence of the injury and the accomplishment of débridement is of almost equal importance with the method employed." Satisfactory healing depends upon the treatment given a wound in the first few hours. There should

be careful splinting at the scene of the injury by the doctor in charge or by the first aid man. The best surgeons should be in the casualty clearing stations and not behind the lines, in the emergency rooms of hospitals and not beyond immediate call. Gone are the days when initial treatment consisted of a resident physician putting a sterile dressing on the patient and sending him to bed to await the morning call of the physician in charge.

2. Careful evaluation of the patient's general condition and an estimate of the degree of shock.

3. If the patient's condition permits, he should be taken to the operating room where, under the best available conditions, all destroyed tissue and extraneous materials should be painstakingly removed from the wound. The fracture should be approximated with as little trauma as possible. We believe that a bone plate should be used to fix the fragments in position unless there is such digitation of the fracture ends that they can be approximated with a reasonable assurance that they can maintain their position.

4. At this point antiseptic drugs such as sulfathiazole may be sprinkled into the wound. I, personally, use sulfathiazole, although, as indicated in Cases I and II, in which one extremity served as a control, wounds seem to heal as well without it in compound fractures when the sympathetic nerve block is used. Also, although in treatment of open wounds the use of polyvalent anaerobic vaccines is common, I believe that they have no great importance and do not use them.

5. The wound should be very loosely closed and drainage insured by a packing of loose gauze. Permitting the air to enter the wound lessens the chances of anaerobic growth.

6. Either a moulded lateral plaster splint or a solid cast should be applied. I favor splints as they enable the surgeon to examine the wound at will and do not necessitate the cutting of a window in the plaster cast when such examination is

necessary. Also, as inflammation and swelling subsides, these lateral splints may be tightened and so maintain more complete fixation of the limb. As Eliason<sup>8</sup> points out, "a leg confined in a cast, after the swelling has subsided, very often rattles like a pea in a pod."

7. The patient should then be turned on his side (the side opposite the fracture) and a novocaine block of the lumbar sympathetic ganglia performed. In cases of deep anesthesia, it is permissible to turn the patient upon his face. We feel that the vasospasm in compound fractures is a transient one and that 20 cc. of 2 per cent novocaine is sufficient to give the results sought.

*Technic of Lumbar Injection.* A wheal is made about 7 cm. from the midline opposite the second lumbar interspace. This falls close to the twelfth rib. Through this wheal more novocaine is injected into the muscular aponeurosis which is quite sensitive. A lumbar puncture needle or a No. 22 gauge needle should next be used. This is introduced at a right angle. Often it meets the tip of a transverse process. If so, it can be withdrawn and reinserted at a 45° angle toward the vertebral body. If it strikes the body, it should be partially withdrawn and adjusted so as to pass the body completely for a distance of about two and one-half inches. There it should lie on the psoas muscle, just behind the aorta or inferior vena cava. At this point extreme care and caution should be used as it is possible to enter the vena cava. A careful pulling back of the plunger of the syringe will tell if it occurs. If this occurs (and it has happened to us), no difficulty follows. Twenty cc. of 2 per cent novocaine are infiltrated into the tissues at this point, which in itself should suffice. To be doubly sure, it is well to carry out the same procedure in the third interspace. In several of our cases I have injected 5 to 10 cc. of 90 per cent alcohol

with no results other than which we wished to obtain.

#### SUMMARY

1. The theory is advanced that some degree of traumatic vasospasm is suffered in all cases of compound fracture or serious wounds of the lower extremities.

2. This theory is based on the supposition that any force sufficient to damage severely the tissues or to fracture heavy bones is sufficient to disturb the blood vessels, directly or indirectly, by damaging the sympathetic nervous system and thus producing arterial spasms of varying degrees.

3. Although the vasospasm passes off in due time, it is postulated that this period of diminished blood supply to the part gives the infecting organisms time to establish themselves.

4. A lumbar sympathetic nerve block, to prevent the interim of diminished blood supply, is advocated as routine in the effective therapeutics of compound fractures and severe wounds of the lower extremities.

5. Several cases of severe compound fracture in which the nerve block was used with highly satisfactory results are described.

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# SEVERE ACUTE INJURIES OF THE KNEE

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CONSIDERING the frequency of severe acute injuries of the knee joint other than fractures and dislocations, the dearth of literature on this subject is rather surprising. McMurray in his essay "The Diagnosis of Internal Derangement of the Knee" states, "Since no joint in the body is liable to such a multitude of severe or trivial injuries as is the knee joint, a clear understanding of the relative values of the various signs and symptoms is essential if the correct line of treatment is to be carried out." Certainly there can be no difference of opinion in regard to this statement and yet there are only comparatively few articles on the pathology, symptoms and diagnosis of the acute trauma. Most writers have dealt with those conditions which are the result of the severe acute injuries such as the internal derangements and the persistent laxity of the ligaments which have resulted in varying degrees of instability of the joint and they have suggested certain surgical procedures for the correction of these conditions.

In that so many of these cases do come to operation, a most likely conclusion would be that the damage done at the time of the initial injury is irreparable without the aid of surgery. But in our own experience and from the reports of others even with subsequent operations the results obtained in a large number of these cases fall far short of those desired in restoring the normal function of the joint. It would seem, therefore, that the greatest possibility in improving our results in these knee cases lies in the early and accurate diagnosis of the initial injury and instituting the proper treatment at that time. This certainly is a problem of no little economic importance.

There is little wonder that injuries of the

knee are so common when the structure and mechanism of the joint is considered. The knee is mechanically a weak joint, being placed between the two longest bony levers in the body, and dependent on its ligaments and supporting muscles for its strength rather than on any particular bony structure. The knee is more than a hinge joint having a definite rotation of the tibia on the femur at the end of complete extension. In addition to this in most occupations and activities when leverage is exerted on the joint it is supporting the body weight and it is at this time that the damage takes place. The range of normal motion of the joint is limited only by the ligaments, and if the joint is carried beyond this, these inelastic structures are obliged to suffer the primary damage and that to the other anatomical structures becomes secondary.

In this paper we have studied the series of 587 cases of severe acute injuries which have occurred in our private practice in the last twenty years. These cover a fairly large percentage of injuries occurring in athletes and industrial workers. From this clinical study we have drawn conclusions which may not be in accord with other observers; however, we believe they are accurate. Along with these observations we have carried out experimental work to support our conclusions and to prove the rational of the treatment suggested although we claim no priority in many features of this.

Briefly our conclusions are: (1) The primary damage is usually to the ligamentous structures and the medial collateral and crucials are the structures most frequently damaged. The damage to the semilunar cartilages are secondary. (2) The effusion in a traumatized knee is practically always due to hemorrhage if the swelling takes place immediately. (3) The disten-

tion of the joint by this blood is one of the greatest factors in producing an unstable joint as well as the hypermotile cartilages

above at its attachment to the internal condyle of the femur but spreads out fan-like below and is attached to the inner

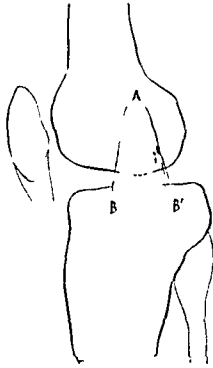


FIG. 1. Shows that the whole ligament is tense in extension.

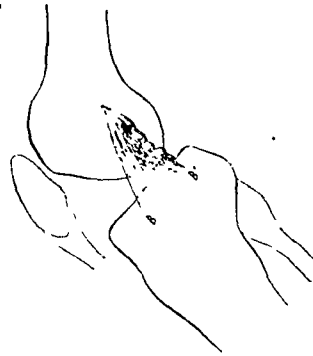


FIG. 2. When knee is flexed, posterior portion of ligament is relaxed.

with the subsequent locking and damage to these structures. (4) That efficient treatment of an injury to the ligaments must: (a) prevent the prolonged distention of the capsule; (b) protect the injured ligaments, and (c) avoid the atrophy of disuse and maintain the muscular tone of the supporting muscles especially the quadriceps and vasti.

#### INJURY TO THE INTERNAL LATERAL LIGAMENTS

In the series of 587 cases a diagnosis of tear of the internal lateral ligament with or without crucial ligament injury was made in 416 cases or approximately 71 per cent of the total. The diagnosis was made on the history of a strain or twist, followed by effusion and tenderness over the head of the tibia at the attachment of the ligament (87 per cent) or over the attachment of the condyle of the femur (13 per cent) and pain, with or without instability, on abduction or external rotation of the leg when the knee is straight. Such findings, when the radiographic examination is negative, justify a diagnosis of injury to this structure.

The internal lateral ligament, the most often injured structure, is one of the most important factors in maintaining the stability of the joint. It is thick and narrow

aspect of the head of the tibia. When the knee is extended, the internal lateral ligament lies exactly over the middle of the inner side of the joint and all of its fibers are tense. However, when the joint is flexed, because of the inward rotation of the head of the tibia, the whole ligament is carried nearer the posterior aspect of the joint and the posterior fibers become relaxed. (Figs. 1 and 2.) If in this position (semiflexion) abduction of the leg is attempted, the strain is thrown on the tense anterior portion of the ligament. This can be easily demonstrated on the freshly dissected knee. The external rotation of the tibia on the femur is limited by the same fibers of the ligament. The internal semilunar cartilage is adherent to the deep fibers of the ligament except for its anterior cornu which is bound to the head of the tibia by that thinned part of the capsule spoken of as the coronary ligament. Both menisci act by their wedge shape in adapting the surface of the head of the tibia to the condyles of the femur in the varying positions. Thus it will be seen that the prevention of abduction in the extended position is due to the whole internal lateral ligament, but that abduction and external rotation are limited only by the anterior fibers of the same ligament when the knee

is partially flexed and before any strain is thrown on the posterior fibers the anterior must give away.

It is true that the crucials also prevent abduction in the extended position, but in the partially flexed position these are relaxed and again the tense anterior fibers of the lateral ligament must give away before the strain falls on the crucials.

The extensor muscles, especially the quadriceps and vastus internus by their fibrous expansion over the inner side of the capsule when they are contracted, are worthy reinforcements in resisting abduction. It is needless to call attention to their importance as stabilizers in the extended position and to a lesser degree even in slight flexion.

Without argument it seems fair to assume that the majority of injuries to the knee takes place with the joint slightly flexed and the traumatizing force carrying the leg into a position of abduction and external rotation. This is almost universally accepted in the literature on the subject and the histories of our cases substantiate this: when sufficient force is exerted in abduction or external rotation, the anterior fibers of the lateral ligament are first to give away. The ligament does not usually tear in the middle from such force but practically always ruptures at or near the bony attachment. In a series of experiments carried out on the knee joints of cadavers we have never seen the internal lateral ligament rupture in its middle but always from its attachment and usually from the tibial head and rarely from the femoral condyle.

In the cadaver experiments ten knee joints were used. All of the muscles about the joints were divided and the inner side of the capsule exposed. The abducting force was applied to the joint with the knee extended in five cases. Three of these gave way from the tibial head, one from the femoral condyle and one from both the condyle and head of tibia. In the five joints in which the abducting force was applied with the knee in slight flexion all showed

that the anterior fibers of the ligament gave away first from the tibial head. The same experiments carried out on living dogs were not as convincing as to the weakest part of the ligament. In both the flexed and extended position more than half pulled away from the femoral condyle. We think this is explained, however, by the different shape of the internal condyle in dogs and the fact that the attachment to the femur is as broad as it is below at the attachment to the tibia and there is no difference in the relaxation of the anterior and posterior fibers when the knee is flexed.

Because of the intimate connection between the semilunar cartilage and deep fibers of the ligament, any force which pulls the attachment of the former away from the head of the tibia must lift the cartilage away from the bone also. It is then evident in that the anterior fibers of the ligament are most frequently ruptured so that the anterior part of the cartilage is most frequently displaced from its tibial head. This coincides with the view of S. Alwyn Smith that "a displacement of the internal semi-lunar cartilage cannot occur unless the internal ligament be stretched or ruptured." In over two-thirds of our cases of internal ligament damage demonstrable abduction was present when the knee was extended.

Hemorrhage into the joint was a common finding in the 416 cases. In the whole series of knee injuries 93 per cent showed macroscopic blood on aspiration. These figures agree with those published by Harding in 1919. This effusion is a factor of the greatest importance in preventing the proper healing of the ligament and cartilage in their proper relation to the head of the tibia. (Figs. 3 and 4.) It usually takes from one to three weeks for the effusion to be absorbed under rest and bandaging during which time the torn ends of the ligament and the cartilage are held away from the head of the tibia. While this is the case, the interval between these structures is bridged across by granulation and young cicatricial tissue which fails to fix the

cartilage closely to the head of the tibia and actually lengthens the ligament. This must result in a loss of stability of the joint.

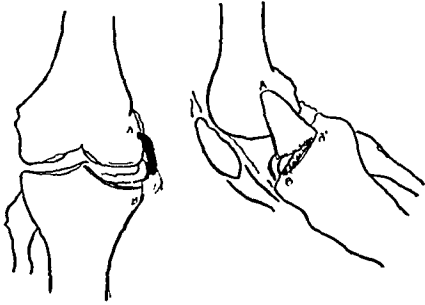


FIG. 3. Shows how distention of joint separates torn ends of internal lateral ligament.

FIG. 4. Shows torn anterior portion of ligament most widely separated by distention.

For the purpose of demonstrating the effect of the effusion in separating the cartilage from the head of the bone, the knee joints of a fresh cadaver were subjected to abduction and external rotation while the knee was semiflexed until the internal lateral ligament could be felt to give away. The joints were then opened through a split patella incision and the interior of the joints examined. The internal cartilages were found to be lying smoothly in their place on the tibial head. The anterior part of the cartilages were then covered with silver foil which was sutured to the cartilage. The joints were closed and sealed with collodin. X-rays taken at that time showed the shadows in their apparent normal position. (Fig. 5.) The joints were then distended by means of a needle and syringe, as much as 100 cc. of fluid being used. Plates then taken in exactly the same position showed the cartilage shadows had been lifted away from the tibial head. (Fig. 6.) This explains the x-ray appearance when the joint is distended with oxygen and the gas shadows show under the cartilage when it is detached.

This would indicate what might be expected in a certain number of our patients treated by simple rest and splinting,

a hypermobile cartilage and an inefficient ligament if no other factors were present. We have already stated that although the



FIG. 5. Shows internal semilunar cartilage in normal position on head of tibia before the joint was distended.



FIG. 6. Shows how cartilage has been pulled away from the head of the tibia when the joint was distended.

muscles of the thigh are not the real factors in preventing lateral mobility of the knee, they are contributing factors and must be taken into account. It is true that these are seldom injured at the time of the sprain but the disuse which must follow rest or splinting results in weakness and atrophy. It has been suggested that the atrophy of the vastus internus in traumatized knees is greater than that of simple disuse. The explanation offered for this is that this muscle is supplied by the same nerve as is the joint. However, by careful observation and measurements in a number of our patients who were splinted at rest for several weeks we have been unable to note any difference in the degree of atrophy compared with those which have been fixed for a similar period for other conditions such as a fractured foot or leg.

In the foregoing we have tried to emphasize that there are three factors of paramount importance in the treatment of the acute injuries of the lateral ligament and internal meniscus:

1. *Prevention of Distention of the Capsule.* Paracentesis has been advised by many for the relief of pain when the disten-

tion is great. Harding and McWilliams have reported excellent results following early aspiration of traumatized joints. The

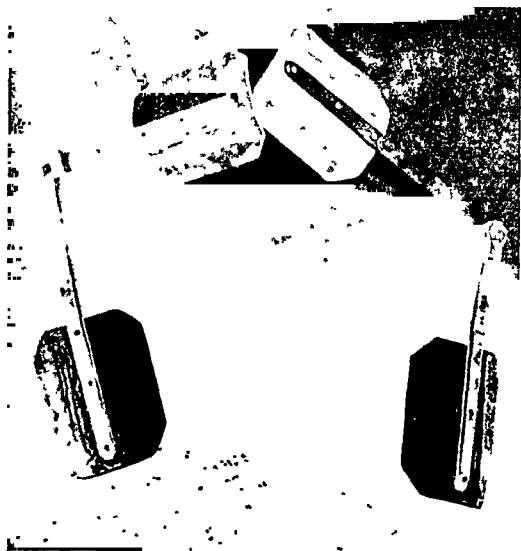


FIG. 7. Shows hinges used in hinged cast.

maximum degree of distention takes place within the first thirty-six hours after the initial injury and this seems to be the most favorable time for aspiration. Our experience has been similar to Metcalf, that is, when aspiration is performed earlier than twenty-four hours the effusion has usually recurred which necessitated a second aspiration. The amount of fluid removed has varied from 30 cc. in the mildly distended joint to 120 cc. in the very tense joints. Following the aspiration the joint is almost entirely relieved of pain and the simple motions of flexion and extension of the joint become free and painless. In nine cases in which the knee was locked and difficulty experienced in reducing the apparently dislocated cartilage, aspiration was done immediately and simple manipulation accomplished the reduction. Whether the distended capsule was the factor in holding the cartilage out of place we cannot say, but the ease of reduction after aspiration was certainly suggestive.

2. *Protection of the Injured Ligaments from All Strain.* Immediately following aspiration a light plaster cast is applied in two sections joined by a pair of special

hinges placed on both sides of the joint which allow flexion and extension of the knee but which prevents all lateral movements or rotation. This allows movement of the knee but protects the injured ligaments.

Our method of application has proved very simple and effective. The hinges are made by the brace maker and are inexpensive. (Fig. 7.) Four strips of adhesive plaster one and one-half inches wide and slightly longer than the section of cast are used. These are applied to the front, back, inside and outside of the thigh so that there will be free ends above and below the cast to be turned over the edge of the plaster and incorporated in it. (Fig. 8.) Without padding several layers of plaster of Paris are applied and the ends of the adhesive are turned over the upper and lower edges and incorporated by covering these with additional layers of the plaster. A similar cast is then applied from the head of the tibia to just above the ankle, a pad of sheet wadding having covered the front of the tibia. After these sections have hardened, the section on the thigh is rotated outward as far as possible and the one on the leg rotated inward as far as possible. While they are held in this position the hinges are applied to the sides of the knee and fixed to the two sections by several additional layers of plaster bandages. (Fig. 9.) After the sections have set they are trimmed around the knee sufficiently both in front and behind the joint so that full extension and flexion to at least 90° is possible. (Figure 10 shows the complete cast and Figure 11 the range of motions possible.) It is to be noticed that the knee can be readily observed and is easily accessible for further aspirations if necessary.

These patients are kept quiet for forty-eight hours after the aspiration, and if no recurrence of the effusion takes place, weight bearing is allowed on the third day. On the fifth or sixth day usually the patients are getting about comfortably with only the use of a cane which they soon discard. As an additional protection to take

FIG. 8.

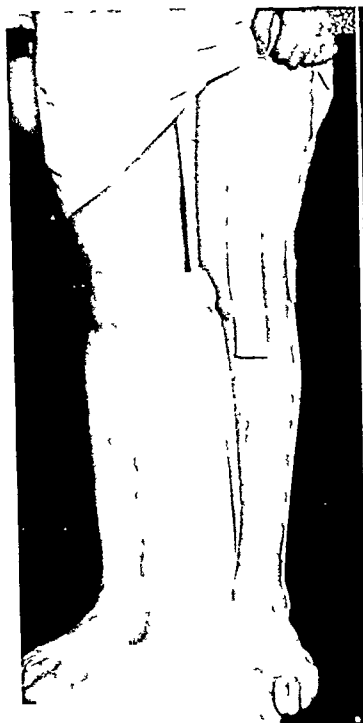


FIG. 9.



FIG. 10.



FIG. 11.



FIG. 8 Shows adhesive strips applied to thigh and calf before plaster is applied.

FIG. 9. Shows the thigh and leg cast joined by the hinges.

FIG. 10. Shows the completed cast properly trimmed.

FIG. 11. Shows range of flexion.



the strain off the inner side of the joint the heel of the shoe is elevated one-fourth inch on the inner side.

3. *Avoidance of Atrophy and Maintenance of the Muscular Tone of the Quadriceps and the Vasti.* The necessity of maintaining the muscular power has been stressed by many writers and the importance of exercise and massage emphasized. We believe that the use of the muscles in walk-

and fully while sitting. He is instructed to carry this out for at least fifty times thrice daily. These are carried out for the six weeks that the cast splint is worn and for several months after its removal. We have been impressed with the moderate atrophy which takes place in patients so treated. When the cast is properly applied and not made heavy, it is surprising how well these patients walk and are often able to get back to light work in a week or ten days.

Several years ago a smaller group of patients with internal lateral ligament damage (this group is included in the present series) who were treated by the method outlined were studied in comparison with a group of similar patients treated by cast or splint and followed by compression bandages or strapping. The results are given in Table 1.

TABLE 1  
247 cases of severe acute injuries of the knee  
168 cases (68 per cent) diagnosed as injury of the internal lateral ligament and semilunar cartilage including 32 cases of rupture of the crucial ligament (anterior) and 9 cases of fracture of tibial spine  
146 cases (87 per cent) showed macroscopic blood on aspiration  
Of the 168 cases, 88 cases were observed over 3 years or more.

	Recurrent Attacks		History of Locking Subsequently		Cartilage Removed	
	No	Per Cent	No	Per Cent	No	Per Cent
Treated by aspiration and hinged cast, 62	11	16	3	5	2	3.2
Treated by cast or posterior splint and bandaging, 26	15	60	6	23	5	19
	Treated by Aspiration and Hinged Cast		Recurrent Trouble		Treated by Cast, Etc	
Crucial ligament complication	7		2		4	2
Fracture tibial spine	4		0		3	1

#### INJURY TO THE EXTERNAL LATERAL LIGAMENT

Injury to the external lateral ligament has been comparatively rare as a single lesion, the diagnosis having been made only twenty-one times in the series. Of course in the most severely injured joints it unquestionably has occurred along with the rupture of the other ligaments when the knee is unstable in all directions. The diagnosis of rupture of the external ligament has been based on the history of an adducting trauma effusion, tenderness over its attachments to the external condyle or the head of the fibula, pain on adduction of the leg on the femur and abnormal adduction mobility. We do not believe that injury to the external cartilage is related to the injury to the external ligament as the cartilage is not attached to it, having the popliteus muscle interposed between these structures. The treatment as suggested for injury of the internal lateral ligament is recommended with the exception, of course, of elevation of the inner side of the heel.

#### RUPTURE OF THE CRUCIAL LIGAMENTS

Injuries and rupture of the crucial ligaments have been grouped with those of

ing is the best exercise and the improvement of the local circulation by such exercise is of decided advantage. This, however, should be carried out only if the proper protection is afforded the injured structures and the cast splint seems to furnish this. Weight bearing and use of the joint is begun as early as the third day after the aspiration and are supplemented by special exercises for the extensor muscles. These simple exercises are carried out by having the patient extend the knee actively

injury to the internal lateral ligament as rupture of the crucials cannot take place without damage to the medial collateral. Pringle has produced rupture of the anterior crucial by flexion abduction and internal rotation but in all of his cases the deep fibers of the internal lateral were also torn. Jones and Smith as well as many others are in accord with this view. In addition to the symptoms of an injury to the lateral ligament, if the anterior crucial is torn, there is abnormal forward movement of the tibia or the femur and abnormal internal rotation when the knee is straight. An abnormal backward movement indicates an injured posterior crucial. We had this finding only six times in our whole number of cases and all of these were in joints that had been completely dislocated. Injury of the crucials was made in 26 per cent of the internal lateral group. The same treatment is indicated in these cases as in the latter although the hinged cast should be worn somewhat longer, for eight weeks at least.

#### SEMILUNAR CARTILAGES INJURIES

We are not prepared to say what percentage of the cases showed meniscus damage at the time of the initial injury. We believe that in practically all of the cases of rupture of the internal lateral ligament from the tibial head the attachment of the cartilage was also torn. But the splitting and laceration of the cartilages is caused by the engaging or pinching between the condyles and tibial head and does not take place until it is traumatized in such a way at least once. That this does occur at times at the initial injury is indicated that the joint immediately locked in fifty-four of our cases. Of course in those cases in which the knee is locked in flexion immediate reduction of the displaced cartilage by manipulation is indicated and also application of the hinged cast made at once. We believe strongly that conservatism should be the rule even in the very severe ligamentous injuries. To operate for a torn or hypermotile cartilage in the acute

stage and to ignore the primary damage to the ligaments that accompanies the condition is the height of poor surgical judgment. In exceptional cases, however, when the laceration of the ligaments is so severe that apposition of the torn ends seems impossible, exploration and suture of the torn structures is justifiable. In these cases it is wiser to delay the operation for at least forty-eight hours after the injury. The same protection and care must be carried out postoperatively as in those treated conservatively.

#### FRACTURES OF THE TIBIAL SPINE

In the series we have encountered twenty-nine cases of fracture of the tibial spine. In practically all of these cases the symptoms of internal lateral ligament injury have been present. In eighteen cases there was demonstrable abnormal forward movement of the tibia on the femur—the so-called rocker sign. The fact that only eighteen out of the twenty-nine cases had this, supports the view of Jones and Smith that fractures of the tibial spine are not always avulsion injuries by the strain on the crucial ligaments but the condition does occur without crucial ligament instability. The diagnosis in all of these cases was made by radiographic findings. This emphasizes again the importance of adequate x-ray study in all acute knee injuries. In only nineteen of our cases was there a block to full extension of the joint. If, as has been stated, such blocking is the most constant symptom of fracture of the tibial spine we were unable to demonstrate it in these cases. Most of our cases have been treated by aspiration and fixation in a straight cast for six or eight weeks. In about one-third the hinged cast has been used and in these we believe we really have gotten better results with much less atrophy and general relaxation of the joint than in those in which the straight cast has been used.

#### BRUISING OF THE INFRAPATELLA FAT PAD

Contusion or bruising of this structure is a definite traumatic entity and is caused

usually by a direct blow on this area of the joint. At other times it is a complication of ligamentous injuries. The diagnosis is made by the swelling and tenderness just below the patella and to either side of its tendon. There is usually a feeling of fullness at this site and pain on full extension of the knee but there is no definite locking or blocking of the joint as seen in the cartilage and tibial spine cases. At times the symptoms do not come on immediately following the trauma but gradually increase for twenty-four or forty-eight hours. In the most acute cases aspiration, if effusion is present, and rest in a plaster cast with the knee flexed to about  $20^{\circ}$  for at least two weeks is indicated. This should be followed by a compression bandage and an elevation of the heel of the shoe on the affected side for an additional two or three weeks. In the milder cases the latter part of this treatment is all that is needed. The diagnosis of this condition was made thirty-one times in this series.

#### SIMPLE TRAUMATIC SYNOVITIS

We have been quite cautious in making a diagnosis and have made it only when most careful examination revealed no injury to any other structure except the synovia. It is difficult to see how a sprain or twist can injure the synovia alone but a direct blow or contusion could conceivably injure this membrane and produce effusion (hemorrhage) and general soreness on movements of the joint. In twenty-seven cases we obtained such a history and only with these symptoms did we believe such a diagnosis was justifiable. In the mild cases a compression bandage and restricted activities were all that was necessary. In four cases in which the effusion was marked the joints were aspirated and in all of these the effusion was hemorrhagic.

Unquestionably, there are other pathological conditions often present which are almost impossible of recognition at the time of the initial injury. Probably the best example of such conditions are the injuries which take place to the articular cartilage or the underlying bone (osteochondritis

dissicans) or the flakes which are chipped off the semilunar cartilages and later give symptoms of loose bodies in the joint. In many cases the injured synovial membrane undergoes hyperplasia resulting in hypertrophied synovial fringes which give a history of repeated pinching. We believe that the latter condition is caused much more frequently by the irritation of a hypermobile or torn cartilage, fractured tibial spine, loose body or the recurrent trauma due to an instable joint. Later operation on injured knees often shows multiple lesions all of which are capable of producing symptoms. Frequently only one structure is damaged by the acute trauma and the others are secondary to the abnormal joint mechanism resulting from it.

One must bear in mind that in consideration of acute injuries of any joint pre-existing pathological processes made be present which often confuse the clinical picture. The condition most frequently met with in the middle age or older group is hypertrophic arthritis. In this condition the ligaments are less pliable and the amount of force required to cause the ligamentous injury is correspondingly less. It has been our observation that joints so affected are much slower in recovery. We do not believe that single acute injury can cause the hypertrophic arthritic changes but certainly these joints are much more susceptible to injury and are slower in clearing up.

Fractures about the knee joint do not come within the scope of this discussion but it must be borne in mind that most of these cases are accompanied by damage to the ligamentous structures. The recognition of this fact and the proper care of the injured ligaments is just as important as the care of the fractured bone. Unless this is fully appreciated many of our cases of fractured knees will have a perfect anatomical result so far as the bone is concerned but still be disabled on account of the unrecognized and untreated damage to the soft tissues.

In conclusion, we would again emphasize that in acute injuries of the knee regardless of which structures are most seriously

damaged the most important points of adequate treatment are the avoidance of prolonged distention of the capsule, protection of the damaged structures and maintenance of muscular tone of the thigh muscles.

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# POST-TRAUMATIC INFECTIONS OF THE EXTREMITIES\*

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THE extent of infection developing after trauma to the extremities depends upon the nature of the wound and the organisms with which it is contaminated. Traumatic lesions may be classified as abrasions, incised, punctured, lacerated, contused and gunshot wounds. The organisms usually found in such wounds include the staphylococcus, streptococcus and the anaerobes that produce tetanus and gas gangrene. For purposes of this discussion the subject will be approached from the standpoint of the usual types of infection encountered in these various wounds.

## ABRASIONS

Since these are superficial lesions destroying the epidermis and opening a portal in the deeper layers of the skin and lymphatics, only the aerobic organisms capable of developing in and immediately under the skin are likely to set up infection. If the staphylococcus gains a foothold, characteristically there will be small pustules developing under crusts that form over the abraded area with a narrow red zone of inflammation in the skin immediately adjacent to the abrasion. If not aggravated by further trauma, such lesions tend to remain localized and superficial causing few symptoms. If the streptococcus predominates, the infection progresses more rapidly, redness about the margin of the injured part appears characteristically and spreads quickly for a considerable distance. Lymphangitis and lymphadenitis in the regional lymph-nodes will probably develop within a few hours and there will be increased heat, redness and intense pain associated with some fever. Blisters may appear on the surface and at the skin

margins. The secretion from this type of wound is usually thin, watery and slightly blood tinged especially in the early stages. The diagnosis is based upon the clinical picture together with smears and cultures from the secretions. The infection usually subsides without invasion of the deeper tissues and most of the acute symptoms disappear if the resistance of the patient is good and proper measures of treatment are instituted early. Because such wounds do not form a suitable medium for the development of tetanus bacilli, this disease is seldom seen but has been known to occur following simple abrasions.

## INCISED WOUNDS

A clean-cut wound made with a sharp instrument produces a minimal amount of tissue injury. Even when numerous organisms are introduced into such wounds, the resultant infection may be slight because the defensive forces of the body are not hampered by the presence of dead and dying tissue. Although it is possible for anaerobic conditions to exist in an incised wound when it penetrates to some depth, these organisms seldom propagate unless muscle tissue has been greatly damaged. The commonest invader, therefore, is the staphylococcus which produces a localized superficial abscess characterized by slight swelling, tenderness and a small surrounding area of redness in the center of which there develops a small focus of necrosis with white purulent exudate. When the staphylococci propagate in the deeper tissues, the infection is likely to be more extensive with greater swelling, tenderness, some fever and leukocytosis. As a rule, early localization and rapid healing follow evacuation of the abscess. A pure strepto-

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coccic infection seldom occurs in this type of wound but mixed infections of streptococcus and staphylococcus may develop to produce a cellulitis characterized by pain, swelling and diffuse tenderness with redness and brawny induration for a considerable distance about the wound. The symptoms appear rapidly and are associated with a greater systemic reaction of fever, malaise and leukocytosis. Localization and resolution of the process is sometimes slow. The discharge may be serous or seropurulent. Smears and cultures of the secretions will reveal a mixed type of infection with streptococci predominating.

#### PUNCTURED WOUNDS

A sharp or relatively sharp instrument may penetrate only the subcutaneous tissues or it may pierce the fascia and injure underlying muscle. The penetrating instrument is likely to carry infection from the skin surface; and if a foreign body such as a splinter or fragment of steel is left implanted in the deeper tissues, the infection is likely to be much more serious. Because there is more tissue damage and anaerobic conditions prevail, there is more danger of the development of infection than in the incised wound. The staphylococcic infection, evidenced by the slow development of a localized abscess in the subcutaneous tissues, is the commonest sequel. Throbbing pain, followed by diffuse swelling and tenderness, and perhaps some febrile reaction will persist for two or three days during which time there will be little or no discharge. Frank fluctuation appears if tissue necrosis and pus formation take place and when the abscess is incised and evacuated, the acute symptoms disappear.

When a punctured wound penetrates fascia and muscle, anaerobic conditions favorable to the development of tetanus and even gas gangrene prevail in the deeper parts of the tract. The development of tetanus may cause little inflammatory reaction unless other organisms are propagating at the same time. Although the wound may heal superficially, in the deeper parts a

small granulating focus may be present which causes active tetanus. The early clinical picture is, therefore, dependent upon the activity of mixed infection rather than tetanus alone. Consequently, the symptoms and physical signs will be those of a staphylococcus or less frequently gas gangrene. The only positive means of demonstrating the presence of tetanus organisms is by culture taken from the depths of the wound or better still from the débrided muscle.

The symptoms of tetanus are caused by exotoxins which are produced rapidly and absorbed by the lymphatic vessels. These enter the general circulation, are carried to the neuromuscular end plates and then ascend the motor nerves of the spinal cord and brain to become inseparably fixed in the nerve tissue. The rate of ascension of toxin in the peripheral motor nerves is comparatively rapid. Diffusion up and down the spinal cord produces a muscular spasm resulting in convulsions.

The symptoms of tetanus depend upon the virulence and number of organisms and the resistance of the individual. The first symptom usually is pain in the region of the muscles of mastication followed by spasm of the masseters. Once trismus has begun, it is progressive and results in the characteristic picture of "risus sardonicus." The jaws are tightly fixed and the patient is unable to swallow even fluids. Muscles of the neck and back then become involved, and as they go into tonic spasm, produce the typical appearance of opisthotonos. The abdominal muscles subsequently become rigid and the normal abdominal excursions of the diaphragm are inhibited, thus diminishing vital capacity and producing varying degrees of cyanosis. Convulsive seizures occur as a result of very slight stimulation and vary in duration and intensity. Occasionally, they are so violent that fractures of the spine or other bones may occur. Subsequently, muscles of the extremities become affected, particularly the flexor group. The temperature may be slight or great and is apparently of no

prognostic importance. Profuse perspiration and profound exhaustion follow the repeated spasms and death by asphyxiation may occur from a prolonged spasm involving the diaphragm and laryngeal muscles.

If the pathogenic anaerobic organisms (*Clostridium welchii*, *Clostridium oedematiens* or *Clostridium oedematis-maligni* (vibrio septique)) are introduced into traumatized muscle and especially if circulation in the part is diminished from swelling or constriction, typical signs and symptoms of gas gangrene may develop rapidly. These will be discussed under gunshot wounds. The diagnosis is based upon the history of a deeply penetrating wound through soiled clothing and skin which has not been treated by suitable preventive measures such as débridement and early implantation of sulfathiazole and the rapid development of the clinical picture of gas gangrene.

#### LACERATED WOUNDS

Lacerated wounds, whether superficial involving subcutaneous tissue or deep involving the fascia and muscles, contain a large amount of damaged tissue favorable to the growth of any of the contaminating organisms. In a superficial wound, however, the anaerobes have less opportunity to gain a foothold so that the accompanying infection is likely to be produced by the staphylococcus or a mixture of staphylococcus and streptococcus. When the staphylococcus alone is responsible for the infection, the symptoms develop slowly, at first being marked by the swelling and redness incident to wound repair. As the infection progresses, these symptoms become more diffuse and intense and the discharge more abundant and of a seropurulent type. If the wound is closed, severe pain develops as swelling increases. There is less pain and swelling when the wound remains open. Rise in temperature and leukocytosis will also vary depending upon whether or not the wound is closed, being greater when it is. In the open wound infection will usually progress to involve

all parts that have been lacerated but not beyond this point. Gradual subsidence usually follows when adequate drainage has been established. Staphylococci may be recovered from the wound secretions in large numbers after the first twenty-four hours. When the streptococcus or the streptococcus with the staphylococcus are the invading organisms, there may be rapid increase in swelling for a considerable distance beyond the wound margin with an outpouring of serosanguineous discharge, rapid rise in temperature, severe pain and leukocytosis. These symptoms are all aggravated in a closed wound and less severe and rapid in development in the open wound.

When the deeper structures have been lacerated, pure staphylococcic or the mixed staphylococcic and streptococcic infections may develop with symptoms similar to those described in the superficial wound except that the systemic reaction of fever and leukocytosis is greater. The wound is deep, the muscle tissue damaged and anaerobic conditions prevail. For these reasons, the tetanus and gas gangrene organisms may propagate and produce a more serious type of infection. The clinical picture is one of gas gangrene appearing in the course of the first twenty-four to forty-eight hours and overshadowing such evidence of staphylococcic or streptococcic infection as may be present. This clinical picture will be discussed under gunshot wounds. The tetanus organisms, even though they may propagate along with the *Clostridium welchii*, will not produce symptoms until a week or ten days later.

#### CONTUSED WOUNDS

Contused wounds differ from the lacerated wounds only in the fact that the surrounding tissues are traumatized and there is frequently considerable devitalized muscle. A hematoma often develops and is easily infected producing a large abscess. The characteristics of infection developing in such wounds are not different from those described except that the extent of necrosis

and sloughing in the later stages is likely to be much greater.

#### GUNSHOT WOUNDS

Gunshot wounds are the severest of all because they represent a combination of punctured, lacerated and contused wounds with the addition of a foreign body. The character and extent of infection naturally vary with the type of projectile and the portion of the extremity traversed. It is usually true that the larger, blunter and slower traveling projectiles are the most dangerous from the standpoint of infection. Steel-jacketed bullets of high velocity may pierce an extremity even grazing or passing through the bone without introducing infection of any consequence. A ragged shell fragment of low velocity, barely penetrating muscular layers, is likely to produce the most serious infection. If the bones are shattered and spicules are driven into surrounding tissues, the possibility of infection proportionately increases. Therefore, compound fractures caused by projectiles other than those of high velocity, are most likely to be accompanied by severe infection. Wounds resulting from shotguns fired at close range in which massive loads of small or large shot penetrate muscular layers accompanied by bits of clothing, dirt and gun wadding will probably produce gas gangrene even when the bones are not shattered.

The deep implantation of various organisms with extensive damage to the surrounding tissues, the presence of foreign bodies and prevailing anaerobic conditions all combine to favor the development of gas gangrene and tetanus rather than a staphylococcal or streptococcal infection. Under such circumstances *Clostridium welchii* propagate rapidly and invade the muscles. Large amounts of toxin and gas are thus produced. These toxins cause death of surrounding tissue and intense edema and when absorbed, strongly affect the pulse rate, temperature and nervous condition of the patient. The gas, accumulating in the muscle layers beneath inelastic fascia,

expands along intermuscular planes under considerable pressure, thus depriving the muscle of its blood supply. This causes additional necrosis and creates new culture media for the rapidly propagating organisms. Thus is initiated a vicious cycle which, when unbroken, results in rapid spread of the infection through all the muscles in the wounded extremity distal to the joint.

The presence of gas gangrene should be suspected from the nature of the injury and the history of failure to institute appropriate preventive measures. The outstanding symptom in the early stage twelve to twenty-four hours after injury is intense pain for a considerable distance around the wound. Although there is always some elevation of temperature during this same period, the characteristic finding is a rapidly rising pulse of full volume and of greater rapidity than would ordinarily accompany the moderate amount of fever. Restlessness, anxiety and thirst are typical. The dressings are frequently soaked with large quantities of serosanguineous discharge characteristically brick-red in color and with a distinct, pungent, nauseating odor. Upon removal of the dressing, the entire circumference of the limb for some distance above the wound is often greatly swollen and tense and the skin is shiny, perhaps mottled, copper-colored and covered with blebs and blisters. Pressure over any part of the distended limb produces intense pain and as the fingers are pushed toward the wound, additional serosanguineous fluid may be expressed, which when carefully observed, is found to contain small gas bubbles. Sometimes these bubbles cannot be seen unless a forceps is inserted into the depth of the wound and sufficient pressure is used to express fluid from the muscular layers. Roentgenograms made at twenty-four to forty-eight hours after injury will reveal the presence of gas bubbles in the muscular tissue for some distance about the wound. The white blood count is usually high but the red blood cells rapidly decrease as



shown in counts made at intervals of four hours. Smears from the depth of the wound which show large numbers of short Gram-positive nonmotile rods and very few other organisms, although not proving the diagnosis, are helpful when considered with other characteristic findings.

#### TREATMENT

The only effective treatment of post-traumatic infections is preventive. Early and thorough débridement of punctured, gunshot and lacerated wounds has long proved valuable. Unless the débridement is begun within six hours of injury and is thorough, experience has shown that it is unsafe to close such wounds primarily. Staphylococcic infections, gas gangrene and tetanus have developed following such early débridement and closure even when skillfully performed. For these reasons, tetanus antitoxin and the combined tetanus and polyvalent gas gangrene antitoxin should be administered routinely. However, primary healing without complications cannot be confidently anticipated by these measures alone. From 25 to 50 per cent of the wounds will break down, suppurate and heal by secondary intention. Such a course is particularly undesirable in compound fractures. The introduction of active immunization against tetanus by the use of tetanus toxoid has proved to be an effective prophylactic measure. A second immunizing dose of the toxoid should be administered shortly after a wound is incurred even when the patient has recently received a full immunizing course of tetanus toxoid.

Since the advent of the sulfonamides, it has been found that their implantation in the débrided wound together with oral or intravenous administration of the drug following the operation has a definite inhibitory action upon the development of infection of all types. Clinical reports indicate diminished incidence but not absolute control of wound infections when these drugs are implanted at the time of débridement performed six hours after injury.

Experimental work has shown that *immediate implantation* of the sulfonamide derivatives at the time of the accident followed by early débridement and re-implantation of the drug is most effective in preventing all infections. It appears from the experimental and clinical evidence that the use of sulfathiazole as a first aid dressing is essential in the prevention of infection of post-traumatic wounds. However, the immediate implantation of sulfathiazole in infected wounds cannot be relied upon as the sole means of preventing infection. Débridement within six hours followed by re-implantation of sulfathiazole may be expected to inhibit the development of infection with such certainty that the wounds may be closed and primary healing expected. These measures, properly employed, are such a valuable adjunct that even internal fixation of fractures may be used with reasonable safety.

Based upon these experimental and clinical observations, the ideal plan of treatment for severe punctured, lacerated and gunshot wounds includes: (1) immediate implantation of 5 to 20 Gm. of sulfathiazole in the wound covered with an occlusive dressing; (2) the use of transportation splints and appropriate shock treatment; (3) thorough débridement within six hours of injury; (4) re-implantation of 5 to 15 Gm. of sulfathiazole depending upon the size of the wound and the extent of contamination; (5) primary closure of the wound, and, in the case of compound fractures, splinting such as would be used for simple fractures; (6) intravenous or oral administration of sulfathiazole postoperatively for five to seven days controlled by the blood level; and (7) daily blood counts, urine examinations and blood level determinations for control of toxic effects of the drug.

#### SUMMARY

The extent of the development of post-traumatic infections of the extremities depends upon the nature of the wound and

the type of organisms introduced. These injuries may be classified as abrasions, incised, punctured, lacerated, contused and gunshot wounds. A staphylococcic or streptococcic infection may develop following abrasions but these are ordinarily of little consequence. The development of infection after incised, punctured or lacerated wounds causes little systemic reaction if the lesion is superficial. However, in deep wounds in which the fascia and muscles have been penetrated, the introduction of streptococcus, staphylococcus and anaerobic organisms is productive of more acute symptoms. The most serious type of infection following a deep puncture is tetanus, characterized by pain and spasm of the masseters, trismus, opisthotonos, convulsions and death. Tetanus antitoxin and combined tetanus and polyvalent gas gangrene antitoxin should be administered routinely to all patients with incised, lacerated or punctured wounds. The severest type of infection follows gunshot wounds because they represent a combination of punctured, lacerated and contused wounds with the addition of a foreign body. Under anaerobic conditions, the deep implantation of various organisms, exten-

sive tissue damage and the presence of foreign bodies encourage the development of gas gangrene. This picture is characterized by intense pain for some distance about the wound, rapid pulse rate out of proportion to the moderate temperature, brick-red serosanguineous discharge and distinct, pungent, nauseating odor. The prophylactic measures of immediate implantation of sulfathiazole as a first aid measure, early débridement and reimplantation of sulfathiazole will prevent the development of this dreaded disease.

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# Lesions of the Gastrointestinal Tract

## CHRONIC ULCERATIVE LESIONS OF THE MOUTH\*

### INCIDENCE OF CANCER IN 2,077 CASES AT BARNARD HOSPITAL

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THREE out of every four chronic ulcers of the mouth are malignant. Only one out of four is benign. Such is the crux of a study of 2,077 mouth lesions used as a basis for this paper. This represents a review of every mouth ulcer from 1904 to 1941 seen at the Barnard Free Skin and Cancer Hospital or Clinic, provided only that microscopic study was made of the lesion.

The significance of this observation, that the majority of chronic mouth ulcers are malignant, cannot be stressed too strongly. It means, to the practitioner or dentist, that any ulcer of the mouth which fails to heal within a week or two is probably due to cancer. Were this fact widely appreciated, the mortality from mouth cancer could be markedly reduced. For early cancer of the mouth is generally curable if properly treated. Proper treatment depends, in large part, upon proper diagnosis.

While the practitioner or dentist is listening to the history of a patient stating that he has had an ulcer in his mouth for a week or more, he may assume at once that the chances are, some three to one, that this ulcer is malignant. He will mentally indict the lesion as malignant before he even looks at it, and his attitude will be, throughout examination, to assume it to be malignant unless positively proved benign. He will not be easily misled by the patient's idea that the sore in his mouth is caused by a bad tooth, or a poor denture,

or that the lip has been burnt by a cigarette or by a pipestem. He will not lull himself into false ease by the knowledge he may already have that his friend, the patient, is syphilitic or tubercular.

What he finds when he examines the patient, his mouth and the ulcer, this paper will attempt briefly to describe. Besides 2,077 pathologically proved mouth ulcers of the Barnard Hospital series, reference will be made to 406 mouth cancers from the private patients of the late Dr. Ellis Fischel;<sup>1</sup> and also to 187 lip cancers from the private patients of Dr. Fischel and of the writer. An attempt will be made to give relatively more attention to the commoner cancerous ulcers of the mouth, and less to the rarer noncancerous chronic mouth ulcers.

#### SQUAMOUS CELL CARCINOMA OF THE MOUTH

Of the 2,077 mouth lesions of the Barnard Hospital series, 1,561 were malignant, an incidence of 75.2 per cent. Of these, twenty-eight were sarcoma, eight adenocarcinoma, two basal cell, and the remaining 1,523 were carcinoma of the squamous cell type. The diagnostic features of these 1,523 squamous carcinomatous ulcers of the mouth were as follows:

*Sex.* Squamous carcinoma of the mouth was found to be chiefly a disease of men, and 91.1 per cent of Dr. Fischel's 406 patients with the disease were males. This

\* From the Department of Surgery, Washington University Medical School and Barnard Free Skin and Cancer Hospital, St. Louis.

percentage is given by other authorities anywhere from about 60 per cent to over 90 per cent.<sup>2</sup>

Lip cancer was found almost exclusively in men, and all of Dr. Fischel's 124 private patients\* with squamous carcinoma of the lip were males. Lip cancer, however, did occur in three women of the Barnard Hospital series, leaving a balance of 784 men with squamous lip cancer. These three women comprised two elderly and inveterate pipe smokers, and one younger woman, also a smoker.

The lip cancer of women is generally not squamous cell but basal cell in type. It begins in the skin of the upper lip, and if untreated may eventually ulcerate into the mouth, as it did in two instances at Barnard.

Tongue cancer occurred relatively more often in women, and of Dr. Fischel's 166 patients, 10.7 per cent were females. Carcinoma of the buccal mucosa occurred even more frequently in women, and Dr. Fischel's 106 patients comprised 14.7 per cent females.

*Age.* The majority of patients of this series were sixty years or over in age, and mouth cancer was frequently observed in all the later decades of life. Very many patients between fifty and sixty also had mouth cancer, but below fifty the disease became increasingly rare. The youngest was a boy of nineteen with squamous cell carcinoma of the lower lip; Hall and Bagby in 1938 recorded fourteen other examples from Barnard Hospital of proved mouth cancer in the second and third decades of life.<sup>3</sup>

*Complexion.* Mouth cancers, like skin cancers, were more common in fair-haired, thin-skinned, freckled individuals; rarer in black-haired, thick skinned patients, and very uncommon in the negro race.

*Habitus.* The lower lip was notably prominent in some patients developing cancer of the lip.

\* The other group of 187 lip cancers, referred to in the article, consists of these 124 private patients of Dr. Fischel's, supplemented by twenty-three other private patients.

*Associated Conditions.* Cancer was very rare in a clean mouth. Cancer was usually found to be associated with foul teeth or

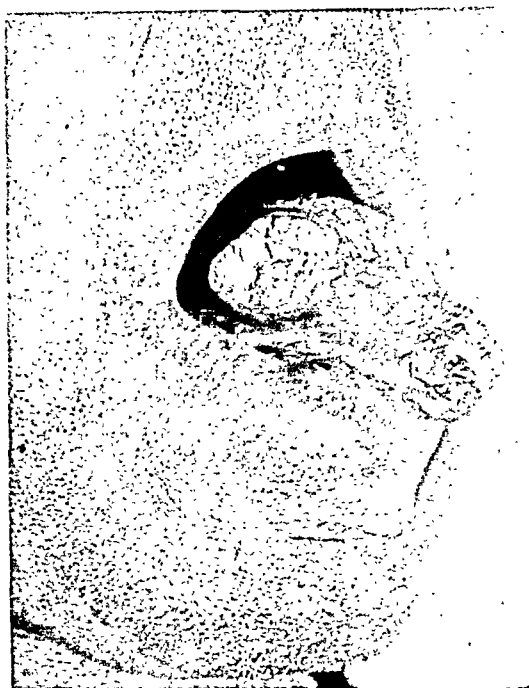


FIG. 1. Typical carcinoma of the right margin of a leukoplakic tongue. Note the rolled, raised border. Diagnosis verified microscopically.

infected gums, or was seen in the mouths of edentulous old men who chewed or smoked a great deal.

Leukoplakia commonly accompanied carcinoma of the buccal mucosa, and was prone to occur within the cheek on the side where the quid of chewing tobacco was held. Leukoplakia accompanied carcinoma of the tongue somewhat less often than it accompanied carcinoma of the buccal mucosa. Leukoplakia also was fairly common with carcinoma of the lip. In the lip, a white patch was prone to occur in the particular spot where a hot pipestem was habitually smoked, and carcinoma was apt to arise later in this location.

The tongue of old men with mouth cancer at times showed evidence of vitamin B deficiency and other nonsyphilitic signs. The tongue was sometimes smooth, with papillary atrophy of varying degree, or deep fissures or cracks and irregular borders. The tongue at other times was

snowed under a mantle of leukoplakia, or showed papillary hyperplasia. Many tongues were heavily coated; some dark brown in color. The breath was often foul.

Signs of syphilis also occurred in some tongues, with scarring and atrophy. Syphilis in this series more commonly accompanied cancer of the tongue than cancer of the lip or buccal mucosa. It is well worth remembering, however, that cancer can exist with syphilis and that a diagnosis of syphilis does not exclude cancer. Fatal mistakes have been made in this connection.

Chronic irritation was observed in many mouths and examples of cancer arising near a jagged tooth were not wanting. Many of the mouths were unusually foul, with snags, exposed roots, pyorrhea, dead teeth, or root abscesses quite the rule. Irritation from improper dentures or poor bridge-work was sometimes seen. Occasionally, however, cancer was seen in a really clean mouth, as for example a very early carcinomatous ulcer seen by the writer between the well kept upper lateral incisor and canine tooth of a young woman of twenty-eight who smoked much and had the habit of brushing the place very hard with a toothbrush. This was unusual, however, and far commoner was it to see cancer in the mouth of a blonde or red-haired, freckle-faced neglectful farmer, tobacco-chewing, pipe-smoking, dirty-toothed or edentulous.

Most of the men and many of the women with cancer of the mouth used tobacco. Yet cancer did occur at times in the mouth of an individual who denied ever having used tobacco in any form. This study in no way attempts to prove whether tobacco influences the origin or growth of cancer in the mouth.

*Previous History.* Many patients had had tooth extractions, often in the presence of a cancer unrecognized by the party removing the teeth. Mistaking cancer of the mouth for an infection, an ulcer, or a "gum-boil" or sore of some kind was quite common; the result was treatment by incision, burning, paste, electricity, etc., often quite unwarranted. A history of a sore

mouth or a sore tongue often preceded the actual development of a mouth cancer.

*Symptoms.* (a) *Lip.* The symptoms of 187 private patients with cancer of the lip were studied especially carefully. The time elapsing between the occurrence of the first symptom and consultation was on the average twelve months. The shortest time was two weeks and the longest was a matter of years. A dozen patients reported five years or more after observing a lesion, probably noncancerous at first, on the lip. Recently, patients have been reporting sooner. Previous to 1930, the average time was one year and five months; since 1930, it has been ten months.

The lesion was described by seventy-three of the 187 patients as a sore or ulcer, and as a fever blister by thirty. It was called a growth, nodule, tumor or lesion by twenty-one, a white spot or leukoplakia by seventeen, a wart, corn, or horn by eleven; six called it cancer, six a pimple, and four a brown spot.

Twenty-one patients complained of no pain; twelve had pain. Itching, dryness, pulling, or smarting was felt by seven. One said his blister enlarged when the moon was full. Some patients complained of tenderness or thickness of the lip, or thought it rough or chapped. Three had a sore or rough mouth.

Progress of the lesion was described by eighty-nine as slow growth, or failure to heal, or healing then splitting. Only six bled. The cancer was attributed by eighteen patients to razor cuts, blows, dental plates, extractions, smoking, burns or bites. A dozen or so noticed lumps or knots under the jaw, two considering them boils, two a pain in the neck.

(b) *Tongue and Buccal Mucosa.* The duration of symptoms at the time of first examination was less with intra-oral carcinoma than with carcinoma of the lip, and was generally less than six months. This led to the deduction that carcinoma within the oral cavity was more bothersome to the patient, and generally more rapid in rate of growth than was carcinoma of the lip. Tongue cancers grew especially rapidly,

less than 6 per cent of the patients surviving over a year untreated.

In general, more patients with intra-oral cancer complained of pain than complained simply of tumor. Thus, many said they had a sore in the mouth or an ulcer or a sore mouth, while relatively fewer stated they felt a mass, lump, tumor or rough spot. Although difficult to evaluate, a certain amount of pain seemed of rather frequent occurrence, though the pain was rarely marked in degree. In this respect intra-oral cancer seemed to differ from lip cancer.

As with lip cancer, so also did patients with intra-oral cancer frequently blame their "sore" on a tooth snag or their white spot to tobacco. Rather often patients thought they had burned their tongues or had a raw tongue from smoking; some said they had painful or stiff tongues; others had difficulty in eating. A few thought they had a "gum-boil" and others a plate ulcer. Few complained of bleeding. There was occasional hoarseness, and sometimes knots, kernels, lumps, or tumors were noted in the neck.

*Physical Findings.* (a) *Lip.* Squamous cell carcinoma commonly occurred in the lower lip, and 120 of Dr. Fischel's 124 cases were located in the lower lip, only four arising in the upper lip. Basal cell carcinoma arose more often in the upper lip, particularly in women. Basal cell carcinoma arises from the skin proper, squamous cell carcinoma from the vermilion or mucous surfaces of the lip. Basal cell carcinoma rarely extends into the buccal cavity itself when properly treated, hence only two examples of basal carcinoma have been recorded in this series, both at Barnard Hospital.

The average diameter of the squamous carcinomas recently observed was 15 mm. The diameter was larger in the earlier cases. The smallest lesion was 5 by 3 mm. and the largest involved the entire lower lip.

Characteristic of squamous carcinoma of the lip was an ulcer or a button-like lesion with rolled, pearly borders, often with induration and infiltration into the deeper

tissues. A scale or crust or yellow membrane covered the granular raw base of some of the lesions. Leukoplakia of the lip or buccal surfaces was frequently noted, and atrophy or scarring of the mucous membranes sometimes occurred. Some of the lesions were ulcerative, some were papillary, and many were button-like; some resembled a wart, some were nodular. Differentiation, clinical or pathological, between early cancer and hyperkeratosis or leukoplakia was sometimes difficult.

Advanced, untreated carcinoma extended onto the alveolus and the buccal mucosa, destroyed the lip, and even involved periosteum or bone. The advancing cancerous edge was usually nodular, hard, with a tendency to ulcerate, leaving a foul, sloughing, bleeding mass behind. Drooling and malnutrition completed the unattractive picture of the very advanced group, but it was interesting how extensive the involvement could be in the lips of some patients with relative freedom of the cervical lymph-nodes from metastases. The converse was sometimes observed: a small primary lesion with extensive cervical metastases.

(b) *Tongue and Buccal Mucosa.* The average size of the tongue lesions when first seen has recently been 3 cm., and for lesions in the buccal mucosa, 4 cm. Lesions 2 cm. or under were relatively rare.

Extensive lesions of the tongue were common, and it was all too frequent to see much of the organ involved. Lesions usually arose on the dorsum of the tongue, but some occurred beneath it spreading onto the floor of the mouth and the inferior alveolus. Lesions of the middle third of the tongue were apt to spread onto the pillars and palate. Lesions of the posterior third spread onto the pharyngeal wall, tonsil, and pyriform fossa.

Extensive lesions of the buccal mucosa were common. They spread to the alveolus, either inferior or superior, or hard palate, and frequently involved the fornix or the angle of the mouth.

Carcinoma of the tongue or buccal mucosa in general resembled a dirty ulcer,

usually with raised, hard borders, often with a granular base, bleeding easily, and apt to be covered with a dirty, yellow membrane. The raised, rolled border usually was characteristic; it was rarely pearly in appearance like it was on the lip. The indurated feel of the border often conveyed a better sense of carcinoma than did the look of the rolled edges.

Carcinomas were of two general classes: ulcerative or papillary. The ulcerative lesions burrowed into underlying tissue, sometimes down to bone. The base almost always felt hard and tended to draw or pucker tissues to it. Thus a carcinoma of the right side of the tongue, middle third, tended to draw to it the velum and floor of the mouth, and to cause deviation to the right of the protruded tongue; or a carcinoma of the fornix would invade the pterygoid fossa and limit the bite as a result. Some carcinomatous ulcers of the buccal mucosa penetrated the cheek, occasionally completely perforating it. Papillary carcinomas were cauliflower-like, ulcerating growths with the same characteristics except for a slower rate of growth.

*Neck.* The cervical lymph-nodes are of great importance with cancer of the mouth. These nodes were found to be palpable in a majority of cases. Often they were small and soft and obviously contained no metastases, an observation usually confirmed when a neck dissection was subsequently performed. In another group were nodes which were somewhat hard, shotty, suspicious of cancer, yet not enlarged. This suspicion of cancer, in such instances, was later verified microscopically in almost 50 per cent of the operative cases. Then came nodes enlarged, hard, still movable, and obviously carcinomatous, an observation generally confirmed in the operative cases. Finally were the group of nodes hard, fixed, and sometimes ulcerating through the skin, the group of hopeless cases.

Cancer spread from the lip first to the submental, submaxillary, buccal, or anterior parotid group of lymph-nodes, homolateral, contralateral, or bilateral, some times years after the cure of the primary

tumor. From the buccal mucosa, cancer spread first usually to the above group of nodes, homolateral always, at a rate generally faster than from the lip. From the tongue, carcinoma usually spreads to the jugulodigastric lymph-node, and almost as quickly to the remaining nodes of the deep jugular chain, extension being generally homolateral, but often contralateral or bilateral, and at much the most rapid rate of the group of mouth cases.

Beyond these first lines of defense, metastatic carcinoma spread, in the absence of neck dissection, to the deep jugular chain of nodes, at first above, then below the level of the tendon of the omohyoid muscle. Finally, metastases spread to the posterior triangle of the neck, and, very rarely, below the level of the clavicle either to mediastinum or elsewhere.

Cancer, in the individual node, entered the peripheral lymph channels, formed follicular deposits, then filled all the node, finally penetrated the capsule, causing the node to become fixed to the carotid artery, mandible, vertebra, or skin, according to varying circumstances.

*Biopsy.* Biopsy was often used to confirm the diagnosis of cancer in the mouth, occasionally in the neck. Gross, not punch biopsy, was favored. With or without infiltration with a  $\frac{1}{2}$  per cent solution of procaine hydrochloride with adrenalin four drops to the ounce, a small piece was accurately cut with a sharp knife from the rolled border of the tumor, including a section through the base of the ulcer and from the adjacent normal mucosa. Light cautery usually effected hemostasis when necessary. Sutures for hemostasis were not employed. The tissue, fixed in 10 per cent formalin, was embedded in paraffin, stained generally with hematoxylin and eosin, and examined by the pathologist at leisure. Frozen sections were rarely used, being much less satisfactory, and not worth the time so saved.

An index of diagnostic acumen was afforded by a study of the 187 lip lesions. The clinical diagnosis was proved correct in 172 of the 187 cases, or 92 per cent. Of

the fifteen lesions diagnosed incorrectly, ten lesions diagnosed clinically malignant proved pathologically benign, and five diagnosed clinically benign proved pathologically malignant.

Biopsy itself was not perfect. A number of lesions, clinically carcinomatous were reported pathologically benign, and later proved actually malignant. Thus a cancer in the lip of a patient previously treated with radium, appeared clinically still to be malignant, but biopsy was reported benign. Nevertheless, because of the clinical conviction that some cancer remained, a "V" excision of the lip was performed, and the clinical diagnosis vindicated by the final pathological section which showed squamous carcinoma. The better trained surgeons looked at the microscopic slides, and correlated the pathological with the clinical aspects of the case.

The most difficult differential diagnosis was between radiation ulcer of the mouth and cancer. Biopsy was almost always necessary to settle this question.

*Regional Incidence of Cancer in the Mouth.* The 1,523 squamous cell carcinomas of the mouth at Barnard Hospital occurred 787 in the lip, 564 in the buccal mucosa, and 172 in the tongue. For the lip, the percentage was 51.7, for the buccal mucosa, 37 per cent; for the tongue 11.3 per cent. In Dr. Fischel's 406 carcinomas, for the lip the percentage was 30.5; for the buccal mucosa, 28.6 per cent; and for the tongue 40.9 per cent. At Barnard Hospital there appeared to be relatively more cancer of the lip and relatively less cancer of the tongue than among Dr. Fischel's private patients.

Partially accounting for these disproportions among tongue cancers were (a) the fact that in the Barnard series pharynx was not classed under tongue, whereas in Dr. Fischel's series it was; and (b) that the Barnard series, being based solely on microscopic data, of necessity omitted the many advanced tongue cancers on which no biopsy was performed. Accounting for the disproportion of lip cancers might be the fact that the indigent farmers at

Barnard were, in general, more exposed to the Missouri sun than were the presumably more protected private patients of Dr. Fischel's series.

Generally, and for convenience, carcinoma of the buccal mucosa has been made to comprise carcinoma of the alveolus, palate or velum. Carcinoma of the tongue has comprised carcinoma of the floor of the mouth, fauces, and, in Dr. Fischel's series, also tonsil, pharynx, and pyriform fossa.

#### OTHER MALIGNANT MOUTH NEOPLASMS

Of the 2,077 mouth lesions at Barnard, 1,561 were malignant neoplasms. Of these 1,561, 1,523 were squamous cell carcinoma, and these have been described. There remain thirty-eight malignant neoplasms, two of which were basal cell carcinoma of the upper lip of females, also referred to above. The balance, thirty-six cases, comprises twenty-eight sarcomas and eight adenocarcinomas.

(a) *Sarcoma.* The twenty-eight sarcomas comprised twelve giant cell sarcoma of the jaw or gum, seven spindle cell sarcoma of the jaw or mouth, three small round cell sarcoma of the jaw, two fibrosarcoma of the lip, and one each of angiosarcoma of the lip, lymphosarcoma of the jaw, osteogenic sarcoma of the gum, and sarroid of the mouth.

Sarcoma sometimes attained huge proportions with distortion in the soft parts from which they arose. They involved the mouth secondarily. Some were slow, some rapidly growing, and a few resembled epulis. They tended to occur in children and young adults, as for instance a giant cell sarcoma of the gum of an 8 year old boy and a spindle cell sarcoma of the cheek of an eleven-year old girl. In sex, as in age incidence they differed from carcinoma. Some were hard, others soft, but since ulceration in the mouth was of secondary importance they need not further be discussed here.

(b) *Adenocarcinoma.* The eight adenocarcinoma arose four in the buccal mucosa, two in the palate, one in the tongue, and one in the lip. They were characterized by



indolent ulcers, slow-growing, with a less marked elevated, rolled, indurated border than squamous carcinoma. Biopsy was necessary for diagnosis.

#### BENIGN MOUTH NEOPLASMS

Of the 2,077 mouth lesions at Barnard, 180 were benign, 1,561 malignant. The malignant neoplasms have been described. The majority of the benign neoplasms comprised sixty-three epulis and fibroma, thirty-eight angiomas of various types, thirty-one polyps or papillomas, and twenty-six cysts.

(a) *Epulis and Fibroma*. There were forty-one examples of epulis, twenty-two of fibroma. Epulis was generally a tumor of late childhood, young adult life, or middle age, and was fairly rare in males. In this series, the forty-one examples all involved the gums primarily, and sometimes the adjacent structures secondarily. A characteristic history was of a persistently growing mass, sometimes of a year's duration, painless, usually unsightly because of its prominent location in the gums, rarely in a really clean mouth. The tumor was soft and elastic, or a hard mass between the front teeth, sometimes pedunculated or sessile. Both gums were apt to be hyperplastic. Extension was usually limited to root sockets and alveolus and the diagnosis rarely in doubt. Occasionally, a suspicious epulis proved to be sarcoma microscopically.

Fibroma in some respects resembled epulis. The distribution in the mouth, however, was different, and the twenty-two examples comprised ten of the tongue, nine of the buccal mucosa, including only four on the gums, and three on the lip. This tumor, relatively more often seen in males than was epulis, generally presented a slow-growing small sessile lump, usually soft. The chief differential diagnostic difficulties were to distinguish it from other benign tumors such as simple cysts.

(b) *Hemangioma and Lymphangioma*. There were thirty hemangiomas or angiomas, and eight lymphangiomas. Hemangio-

mas occurred sixteen times on the lips or adjacent mouth, and fourteen on the tongue. The tumors were soft, slow-growing over many years, painless, rarely bleeding, very rarely ulcerating, usually fairly small, characteristically blue and soft, occurring at almost any age.

Lymphangiomas occurred in five tongues, two lips and one gum. These were soft, slow-growing, bulky tumors, with indefinite borders, generally of younger years, and very rarely ulcerative.

(c) *Papillomas and Polyps*. There were twenty-nine papillomas and two polyps. The papillomas were distributed as follows: twelve on tongues, nine on lips, three on buccal mucosa and one on the gum. These lesions were slow-growing, localized, soft enlargements of a papilla, occasionally ulcerating, rarely painful, obviously benign, occurring in later years, with almost equal distribution between the sexes.

(d) *Cysts*. Of the twenty-six cysts, twenty-three were simple and three dermoid. The simple cysts occurred in eight lips, seven jaws, five buccal mucosae and three tongues. The dermoids occurred in one tongue and two cheeks. Cysts included ranula of the floor of the mouth. The age group was young, some cysts being congenital. Symptoms were due to the size of the cysts and their situation. Since cysts rarely ulcerated, no further description is necessary. Bone cysts and tumors have been omitted from this study.

(e) *Miscellaneous*. The balance of the benign tumors comprised nine mixed tumors, five on the palate, three on the buccal mucosa, one of the lip. These rarely ulcerated, and were slow-growing, small tumors of younger ages, sometimes diagnosed without biopsy. The balance of benign tumors comprised three adenomas and three myxomas of mucous surfaces, and three nevi of the lip.

#### BENIGN ULCERS OF THE MOUTH

There were 186 inflammatory ulcers among the 2,077 Barnard cases. Of the 186 cases, 149 comprised simple inflammatory

ulcers, and thirty-seven were granulomatous lesions including tuberculous and syphilitic lesions.

(a) *Simple Inflammatory Ulcers.* There were six subdivisions of the 149 ulcers in this category, namely, pyogenic ulcers, radiation ulcers, ulcer due to dental plates, syphilitic ulcers and tubercular ulcers, and ulcers associated with carcinoma.

Simple pyogenic ulcers of nonspecific nature formed about 65 per cent of the 149 ulcers of this group. These were of three general types: those occurring alone, those occurring with leukoplakia, and those occurring along with cancer, a type comprising some 25 per cent of the 149 ulcers. The borders were generally flat, soft, fairly regular. The base was usually granular and soft with little infiltration. In size they were small. Some were mere cracks or fissures. When they occurred with leukoplakia they were especially dangerous because of the likelihood that they contained cancer. The etiology of simple ulcers was not easy to establish when carcinoma, syphilis and tuberculosis had been excluded by general physical examination, and by appropriate chest roentgenograms and laboratory tests, including Kahn or Wassermann reactions, and by dark field examinations. Some were due to Vincent's disease; some were nonspecific.

Radiation ulcers formed about 10 per cent of the 149 ulcers. Radiation ulcers followed the treatment of some mouth cancers by radium, and these ulcers sometimes closely resembled the original cancerous ulcer. Radiation ulcers were apt to be indolent and very dirty. The borders were generally indurated but were less rolled than were the borders of a carcinomatous ulcer. The base of a radiation ulcer generally contained a foul slough due to infection with saphrophytic and anaerobic organisms in symbiosis with pyogenic bacteria. The base as a result was apt to be infiltrated, fixed and hard, and often the cause of the pain which was a prominent feature of these ulcers.

Pain and chronicity were two important

points in differentiating them from cancer. Biopsy or excision often proved necessary for diagnosis. It was always imperative to determine the presence or absence of carcinoma in such ulcers.

Plate ulcers formed some 10 per cent of the 149 simple ulcers. They occurred usually in women and were caused by ill-fitting dentures. The ulcers were generally of long standing, often painful. They were generally single and arose in the gum where the plate rubbed. They were usually small, their edges raised but slightly, and were soft, with a clean base, granular but not fixed. The diagnosis was easy when healing quickly followed the leaving out of the denture. Occasionally, excision was necessary for cure or for biopsy. At least one patient developed cancer later at the site of a plate ulcer.

Some syphilitic ulcers, especially on the tongue, clinically and histologically appeared to be mere chronic pyogenic ulcers. Less than 10 per cent of the 149 ulcers of this group fell under this heading. These ulcers resembled the simple ulcers in the preceding paragraph, but they were more apt to be dirty and ragged, and to occur in young adults with positive serology.

Tuberculous ulcers formed about 5 per cent of the 149 ulcers of this group. These ulcers were not unlike simple ulcers except that they were sometimes dirty and punched-out, occasionally quite painful. Associated pulmonary tuberculosis was the rule in these cases.

(b) *Granulomatous Lesions.* There were thirty-seven granulomatous ulcers of which fourteen were tubercular, five syphilitic and the remainder of nonspecific origin. These tubercular and syphilitic ulcers were so diagnosed microscopically, those of the preceding section clinically without a characteristic histological picture.

Tuberculous lesions were fairly deep, dirty, punched-out ulcers, sometimes with rolled borders, occurring usually in patients with pulmonary tuberculosis. Some of these ulcers were quite painful. The biopsy was usually characteristic.

Syphilitic ulcers were more rare than one might expect from the literature. To the five cases diagnosed microscopically must be added a small number described in the preceding section. The five cases showing typical histology occurred in one lip, two tongues and one was a gumma of the palate. The lip lesions were generally indurated and button-like ulcers with a rather dirty base, the induration sometimes being suspicious of carcinoma. Ulcers on the tongue were dirty and irregular.

For a discussion of mycotic and yeast infections of the mouth, the reader is referred to an article by Dr. M. Moore of Barnard Hospital.<sup>4</sup>

#### DEGENERATIVE LESIONS OF THE MOUTH

There were 150 degenerative lesions among the 2,077 pathological lesions at Barnard Hospital. Degenerative lesions comprised sixty-two leukoplakias, fifty-nine keratoses or hyperkeratoses and twenty-nine hyperplasias. Leukoplakia has already been described in some detail in the section dealing with mouth cancer, with which it was frequently associated. The sixty-two leukoplakias here under discussion occurred without carcinoma at the biopsy site, biopsy usually being taken to rule out carcinoma. The sixty-two examples of leukoplakia were distributed as follows: thirty-four in the buccal mucosa, twenty-two in the lip and six in the tongue. This distribution was similar to the distribution of leukoplakia when associated with mouth cancer. Leukoplakia generally occurred in the same relative age and sex groups as did carcinoma, namely, it was relatively common in elderly tobacco-chewing, blonde males.

The duration of leukoplakia was an important point in its differentiation from carcinoma. Often leukoplakia was of many years' duration. Most patients characterized it as a white patch usually symptomless, sometimes rough or cracking or ulcerating. Physical examination revealed a white or pinkish, granular, veil-like deposit in the leukoplakic regions, usually confluent, sometimes patchy, usually

slightly raised, often dry. Cracks, fissures, and ulcers occurred with it, varying from simple small ulcers to frank carcinoma.

The importance of leukoplakia lay in its relation to carcinoma. Carcinoma fairly often arose in a patch of leukoplakia, and it was at times extremely difficult clinically, or even microscopically, to distinguish between leukoplakia and carcinoma. Some leukoplakic patches on the dorsum of the tongue or on the buccal mucosa were white or pinkish, thick, velvety and deeply fissured. While no true rolled border might be evident and no real induration of the base present, it was especially important to suspect cancer and to take an immediate biopsy, being sure to cut very deep. Negative biopsies in such cases were also to be suspected unless the entire lesion had been excised with a minimum margin of 1 cm. of normal tissue all around.

Leukoplakic white patches of the lip at times merged imperceptibly into cancer. The border would pile up and tend to become pearly, the centers to become pitted, depressed and ulcerative, and finally frank cancer to develop.

Keratosis or hyperkeratosis occurred in fifty-four lips and five tongues. These lesions occurred usually in the type of individual apt to develop mouth cancer. The keratotic patch was apt to occur in the spot on the lower lip over which a hot pipe stem habitually was held. It was apt to occur at the place where paper from a cigarette would stick.

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# CARDIOSPASM

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*Definition.* Cardiospasm, second only to carcinoma as a cause of dysphagia, is a disturbance in the nerve-muscle mechanism of the esophagus whereby the esophago-gastric junction remains in a state of partial or complete contracture and produces epigastric pain, dysphagia and regurgitation of food. In association with the area of contraction at the cardia there usually is more or less dilatation of the esophagus above the point of obstruction.

Various terms have been employed to describe the condition, none of which has been universally accepted because of uncertainty of the cause and exact nature of the disease. Among those that have been suggested are diffuse dilatation of the esophagus without anatomic stenosis, hiatal esophagismus, phrenospasm, achalasia of the cardia, esophagospasm, ectasis of the esophagus, idiopathic dilatation of the esophagus and congenital dilatation of the esophagus.

*Frequency.* Cardiospasm is responsible for symptoms in approximately one-third of all patients who suffer from difficulty in swallowing. Several thousand cases have been reported in medical literature, and some authors have reported several hundred cases.

*Age, Sex, and Racial Distribution.* Cardiospasm may be observed at any age, but is most frequently seen in the third decade of life. In the white race males are more often affected than females; although I have observed many negro women with the disease, I have seen the condition in only one negro man.

*Etiology.* The etiology of cardiospasm is debatable, although clinical symptoms and postmortem findings suggest that degenerative changes in the vagal nerve ganglia permit overactivity of the sym-

pathetic nerve elements, thus producing continuous spastic contraction of the terminal portion of the esophagus. Lack of a well defined sphincter muscle at the cardia and absence of muscular hypertrophy, except in the wall of the esophagus above the area of stenosis, are factors that have seemed to invalidate cardiospasm as a descriptive term for the disease.

*Pathology.* The gross pathologic changes observed in the esophagus of patients who have suffered from cardiospasm depend upon duration of symptoms and the degree of dysphagia. In cases of average severity the cardia is tightly contracted and the wall of the esophagus above the area of stenosis is moderately dilated. Portions of the wall may be three or four times thicker than normal, whereas in other areas the wall is much thinner than normal. If there has been little or no retention of secretion and food in the esophagus, the mucous membrane may appear normal; but whenever the esophagus is widely dilated and angulated and secretions have been retained for any length of time, the mucous membrane becomes hypertrophied and ulcerated, and large white macerated areas may resemble malignant degeneration.

Malignant change has occurred in the esophagus in a few cases of cardiospasm, but I have not observed carcinoma at the cardia in any patient who previously had cardiospasm. It is my belief that when carcinoma is found at the cardia in patients with cardiospasm, the original lesion was carcinoma and was confused with cardiospasm. Microscopic studies of the esophagus of patients who have died from cardiospasm, in whom degenerative changes have been demonstrated in the vagal nerve fibers, have not been accepted as authentic

because similar postmortem degenerative changes have been observed in patients who have not had cardiospasm.

*Symptomatology.*—The three cardinal symptoms of cardiospasm are pain, dysphagia and regurgitation of food. Pain occurs in from 60 to 70 per cent of the cases and varies in intensity from mild epigastric discomfort to attacks of such severity that hypodermic injections of morphine may be required for relief. In location, severity and distribution the attacks may resemble gallstone colic or coronary heart disease. Pain usually begins in the epigastrium and may radiate sub-sternally to the neck, ears and lower jaw, sometimes extending down one or both arms to the elbows.

Often epigastric pain is the initial symptom of cardiospasm and may antedate other manifestations of the disease for months or years. The pain of cardiospasm is usually more frequent and of shorter duration than that of gallstone colic. Absence of jaundice and local soreness over the gallbladder are other features that may be helpful in distinguishing the pain of cardiospasm from that of gallbladder disease.

Even after dysphagia develops, pain usually is not associated with the act of swallowing but occurs at any time, often at night, waking the patient from a sound sleep. Dysphagia is present in practically all patients who suffer from cardiospasm, although sometimes the patient may be unaware that obstruction occurs in the esophagus and may believe that food enters the stomach before being regurgitated. Although varying in intensity, dysphagia is usually continuous from the onset.

The initial difficulty is frequently experienced on drinking cold water, and throughout the disease solid food can be swallowed more readily than liquid. Apples, popcorn and all cold liquids, particularly carbonated beverages, intensify dysphagia. The trouble is usually more pronounced when the patient is eating in a public place or when guests are present in his home. The fear of

regurgitation under such circumstances undoubtedly aggravates dysphagia.

At onset of dysphagia there may be loss of weight and strength for a time, but then the patient reaches a level at which the weight is maintained on a restricted diet. A portion of the lost weight may actually be regained if the patient learns to force food through the cardia. This may be accomplished by first taking solid food into the esophagus, drinking a glass or two of water, inspiring deeply with the chin on the chest, and increasing intrathoracic pressure by contracting the thoracic and abdominal muscles without permitting air to be expelled from the respiratory tract. In this manner food can frequently be forced into the stomach in considerable amounts. This procedure is not without risk, however, as in one of my patients spontaneous pneumothorax developed following this method of forced deglutition.

Complete symptomatic obstruction of the esophagus is often noted in cardiospasm, and one of my patients had to take all food through a gastrostomy tube for eighteen years. During this time saliva that accumulated in the esophagus had to be regurgitated at frequent intervals.

At onset of dysphagia food may be regurgitated immediately after it is swallowed or as soon as it becomes obstructed at the cardia. As the disease progresses and the esophagus becomes dilated, food and secretions are retained in the distended sac for a longer time. Sometimes food is regurgitated that has been ingested several days previously. Retention of food in the esophagus may lead to regurgitation and strangulation at night. The patient may not be awakened by the cough associated with strangulation; others in the house may be disturbed, however, and the patient may find that his pillow has been discolored by material he has regurgitated. Regurgitation of blood in small or even large amounts is noted occasionally and unquestionably results from ulceration associated with retention of food in the esophagus.

Pulmonary symptoms are often associated with cardiospasm and may vary from dyspnea after meals, caused by pressure on surrounding structures from a dilated esophagus filled with food, to pulmonary abscess resulting from regurgitation of material from the esophagus and aspiration. Chronic pulmonary suppuration often follows repeated aspiration of food that is regurgitated during sleep.

In a case reported by Shelburne<sup>9</sup> a dilated esophagus filled with food was interpreted as an abscess in the mediastinum on roentgenoscopic examination because in association with regurgitation and aspiration of food, pulmonary infection had developed with fever, cough, leukocytosis and other evidences of suppurative disease. When exploratory puncture of the mediastinal mass revealed material identified as coming from the esophagus, further studies were made and the true nature of the tumor was recognized.

Syncopal attacks have been observed in patients with cardiospasm, and in a few instances sudden death has occurred, evidently from vagal origin. In the patients whom I have observed, the symptoms of cardiospasm have usually been present approximately seven years.

*Clinical Findings.* In the usual case of cardiospasm general physical examination is essentially negative except for loss of weight that is proportional to the degree and duration of dysphagia. Alteration in the sounds heard over the esophagus with a stethoscope during deglutition were formerly mentioned as significant in the diagnosis of cardiospasm, but probably have little or no value. In severe cases emaciation and dehydration may be pronounced, and pulmonary infection may be apparent.

Studies of the blood may reveal leukocytosis if infection in the lung is acute, or dehydration may result in concentration of all the elements of the blood. Severe hemorrhage from the esophagus is seldom seen in cardiospasm, but when it occurs, secondary anemia may be present.

*Roentgenoscopic Examination.* If a patient suffering from difficulty in swallowing is in fairly good physical condition and can swallow soft food with a reasonable degree of comfort, roentgenoscopic examination of the esophagus should be made, using a suspension of barium sulfate in water as contrast medium. This may be flavored as desired. If, however, dysphagia is severe and the patient dehydrated and emaciated, roentgenoscopic studies should be deferred until provision has been made for removal of the barium from the esophagus or the patient has swallowed a thread to permit stretching of the area of obstruction. Unless such precautions are observed, barium may complete occlusion of impending stenosis, and gastrostomy for feeding may become necessary.

Roentgenoscopic examination in cardiospasm reveals a smooth cigar-tip type of obstruction at the cardia with more or less dilatation of the esophagus above the point of stenosis. The esophagus may be diffusely dilated and fusiform, S-shaped or flask-shaped. If food is present in the esophagus, areas of irregularity may be noted and may arouse suspicion of malignancy.

Roentgenoscopic study is of value in differentiating other lesions in the esophagus from cardiospasm, especially diverticulum just above the cardia, hiatal diaphragmatic hernia and diffuse spasm of the esophagus.

*Special Examination.* By chemical and physical methods material that has been regurgitated or aspirated from the esophagus in cardiospasm can usually be distinguished from food or secretion that has been vomited from the stomach.

Esophagoscopy may be useful in the diagnosis and treatment of cardiospasm, but it is not indicated nor desirable in all cases. The necessity for evacuation of all food and secretion from the esophagus during esophagoscopy makes endoscopic study in cardiospasm particularly disagreeable to the patient, and when areas of ulceration are revealed, differentiation from carcinoma may be impossible. Esoph-

agoscopy may be helpful in patients with complete symptomatic obstruction of the esophagus from cardiospasm in facilitating passage of a feeding tube into the stomach, thus obviating the necessity of gastrostomy.

When the esophagus is widely dilated or angulated, the cardia may be difficult to identify. A more helpful method than esophagoscopy in ascertaining that obstruction at the cardia has resulted from spasm is the passage of a No. 60 French sound into the stomach, guided by a previously swallowed silk thread. If there is nothing more than slight elastic resistance at the cardia to passage of the sound, the diagnosis of cardiospasm is practically assured.

*Differential Diagnosis.* Cardiospasm must be distinguished not only from all lesions in the esophagus that cause dysphagia, but also from lesions that produce acute abdominal and thoracic pain, especially gallstones and coronary heart disease. Secondary manifestations of the disease must also be distinguished from suppurative pulmonary disease and from various lesions that produce attacks of syncope.

Of the lesions in the esophagus that may be particularly difficult to differentiate from cardiospasm, carcinoma is the most frequent and most important. Carcinoma of the cardiac end of the stomach, particularly the scirrhus or "leather bottle" type, may produce smooth obstruction on roentgenoscopic study, and symptoms of dysphagia may have been noted for a year or longer. On passing sounds through the cardia, however, dense obstruction is encountered, which serves to distinguish the lesion from cardiospasm.

Cicatricial stricture seldom occurs at the cardia, and organic stenosis at this area almost always results from carcinoma. Epiphrenic diverticula of the esophagus may cause symptoms that resemble those of cardiospasm, but careful roentgenoscopic study is usually sufficient for identification.

Herniation of a portion of the stomach through the esophageal hiatus in the diaphragm, either so-called congenital shortening of the esophagus with hernia, or para-esophageal hernia, may produce symptoms that suggest cardiospasm; but in hernia gaseous distention is more often observed, and dysphagia is usually of an intermittent type. Roentgenoscopic and esophagoscopy examination is required to determine the type of hernia and to differentiate it from cardiospasm.

"Peptic ulcer" of the esophagus is usually ulceration at the junction of the esophagus and stomach in congenital shortening of the esophagus with hernia and is not a primary lesion. As the area of ulceration heals, contraction frequently occurs and stricture develops. Since the point of stenosis is located just above the diaphragm, hernia with stricture must be differentiated from cardiospasm, which can be done by roentgenoscopic study, passage of sounds through the esophagus and esophagoscopy.

#### TREATMENT

*Medical.* Many drugs that act antispasmodically have been utilized in the management of cardiospasm, but for the most part the results of medical treatment have been disappointing. At times pain is sufficiently intense to require hypodermic injection of morphine, but as pain is of a recurring nature, administration of narcotics should be avoided because of the danger of drug addiction.

Belladonna or atropin have been used extensively in an effort to relieve both pain and dysphagia. One of my patients obtained temporary relief from dysphagia by the use of hypodermic injections of atropin sulfate. Increasing amounts of the drug became necessary to produce the desired results until at the time of my observation,  $\frac{1}{8}$  gr. was used hypodermically at each injection. After injection of the drug, dysphagia was relieved for an hour or more, during which time food and fluid were ingested in large

amounts. Soon afterward esophageal obstruction became complete again, and all food, fluid and swallowed saliva were regurgitated until a similar dose of atropin sulfate was administered hypodermically. In the majority of patients, relief, even of a temporary nature, is not obtained by antispasmodic drugs. I have given injections of atropin sulfate in doses of  $\frac{1}{25}$  gr. every hour until the patient showed evidence of acute poisoning without producing relaxation of the cardia.

Occasionally, the use of tincture of belladonna in doses of 15 to 20 drops every three or four hours has seemed to relieve pain which might persist at the cardia after dilatation of the area of spasm. Nitrites have been recommended in treatment, but I have not seen beneficial results in the few patients for whom I have used this form of medication.

Local treatment of ulceration in the esophagus through an esophagoscope is of no value because ulceration results from stagnation of food, and until relief from obstruction can be obtained, ulceration will persist. Frequent passage of a stomach tube into the esophagus for feeding or lavage is not advisable. One patient, whom I observed, produced severe hemorrhage from trauma in the lower portion of the esophagus by this practice.

When dehydration and emaciation are present, introduction of fluids, usually a solution of normal saline containing 10 per cent glucose, should be given intravenously in adequate quantity. This treatment may be supplemented by subcutaneous injection of fluid and also by proctoclysis. Transfusion of whole blood or blood serum may be advisable in certain patients.

*Surgical.* Many surgical procedures have been employed in the management of cardiospasm. One of the earliest forms of surgical treatment was the relatively simple procedure of opening the stomach and dilating the cardia manually. In two of my patients this method was used because tortuosity of the esophagus prevented introduction of a dilator from above.

When this operation becomes necessary, location of the cardia is facilitated by having the patient swallow a thread prior to exploration, the thread serving as a guide to the cardia for the fingers which are introduced into the stomach.

Plastic operations on the cardia, such as are employed in congenital hypertrophic pyloric stenosis, have also been utilized in cardiospasm but with indifferent results. In marked dilatation and angulation of the esophagus esophagogastrostomy has been performed, but the risk of the operation is high and functional results have not proved satisfactory.

Accumulating evidence that cardiospasm is the result of overaction of the sympathetic nerve supply of the cardia has led to operations designed to interrupt the sympathetic nerve fibers enervating this portion of the esophagus. A few fairly satisfactory results have been obtained by removing sympathetic ganglia in the splanchnic area, whereas other surgeons who believe that the major portion of the sympathetic nerve supply of the cardia originates in the cervical area, have resected the cervical sympathetic ganglia. Probably complete or almost complete removal of the sympathetic nerve fibers that control the contracting function of the cardia would relieve symptoms of cardiospasm, but it is likely that enervation is derived from many areas and that complete sympathectomy is impossible.

Gastrostomy as a palliative operation is seldom necessary and whenever it has been performed, usually indicates ignorance of manifestations of cardiospasm or neglect in treatment.

*Dilatation.* Mechanical stretching of the cardia has proved the most effective method for treatment of patients with cardiospasm. As indicated under "Treatment"—"*Surgical*," dilatation of the cardia has been accomplished in a few patients by opening the stomach through an abdominal incision and stretching the area of spasm by introducing several fingers from the stomach into the esophagus. A simpler



and more satisfactory method of dilating the cardia is by introduction of sounds or a dilator that can be distended in the esophagus, through the mouth, guided into the stomach by a previously swallowed silk thread.

The thread should be twisted and not braided silk, and size D is usually small enough to be swallowed easily and yet strong enough to provide sufficient guidance for the dilator. When the thread is swallowed at the rate of about a foot an hour, it will pass through the esophagus into the stomach and coils of small intestine so that after fifteen or twenty feet have been swallowed over a period of twenty-four hours, it can be drawn taut without being pulled out of the stomach. When the thread is thus fixed, it will permit guidance of sounds through the area of obstruction. After the thread has been utilized as a guide and dilatation has been accomplished, the thread outside the mouth is cut off and the portion which has been swallowed will pass through the gastrointestinal tract and be expelled in the feces.

If symptomatic esophageal obstruction is pronounced, the patient may have some difficulty swallowing a thread, and perseverance will be required before a sufficient amount is ingested to permit its use as a guide for passage of dilators. When a patient has failed to swallow a thread after attempting to do so for several days, many ideas may be suggested to facilitate its passage into the stomach, one of which is to tie a shot to the end of the thread. It has been my experience, however, that any method other than the simple procedure of taking the thread on the tongue and ingesting it slowly and continuously is neither desirable nor effective. If a patient has complete obstruction of the cardia and difficulty is encountered in swallowing a thread, esophagoscopy may be necessary in order to introduce a tube into the stomach for feeding. It is advisable, however, to continue to insist for an indefinite period of time that the patient attempt to

swallow a thread before esophageal instrumentation is employed.

In case it is found to be impossible to enter the stomach with an esophagoscope, soreness of the throat occasioned by esophagoscopy will further interfere with deglutition and may necessitate gastrotomy for feeding.

After a thread has been swallowed, the cardia should be dilated with sounds. A blunt olive, No. 41 French, is first introduced into the stomach over the guiding thread, and if obstruction is not encountered, it is followed by passage of a No. 60 French sound. Approximately 10 per cent of the number of patients so treated will be relieved temporarily from all symptoms. In half of the patients who obtain relief, symptoms do not recur.

In those who have recurrence of symptoms and in the larger group who do not obtain temporary complete relief from dysphagia by passage of sounds, the cardia should be distended with some type of expanding dilator. For this purpose I prefer the Russell hydrostatic dilator that was made popular by Plummer. The dilator is introduced over the guiding thread into the cardia and is expanded with water, usually to twenty-six or twenty-eight feet of water pressure. This almost always causes pain and a small amount of bleeding, but following dilatation all types of food can be swallowed normally, and in 75 per cent of cases relief from symptoms is permanent. In the remaining cases there may be mild recurrence of symptoms during the six months following dilatation, but in the majority of patients complete relief will be obtained by repeating the treatment. Recurrence almost never happens in a patient who obtains relief for six months following treatment.

Epigastric pain following passage of sounds or stretching with the hydrostatic dilator may be sufficiently severe to require hypodermic injection of morphine sulfate, gr.  $\frac{1}{6}$  to  $\frac{1}{4}$ . The pain may occur immediately after the cardia has been

dilated or twenty-four to thirty-six hours later. When pain is mild, it may be relieved by sipping hot water, but when it is persistent, 15 drops of tincture of belladonna three or four times a day may afford relief.

Inflation of an expanding dilator with air is not so satisfactory as using water pressure because air is more difficult to control, and adequate pressure with air is not easily obtained. I have not used Hurst's mercury bougies, but I do not believe they can be introduced through the cardia so comfortably, accurately, or safely as sounds guided by a previously swallowed silk thread.

**Prognosis.** If dilatation of the cardia with a hydrostatic dilator is reserved for patients who have not obtained relief from passage of a No. 60 French sound into the stomach, the danger attending dilatation of the cardia in cardiospasm is negligible. In over a thousand consecutive dilatations of the cardia with sounds and a hydrostatic dilator during the past fifteen years I have not had one serious complication.

Relief from symptoms occurs immediately following treatment, and significant recurrence of discomfort is rarely observed. Patients who require treatment more radical than dilatation are seldom seen. Probably the majority of patients who have been subjected to radical treatment could have been relieved by much simpler procedures. Failure to relieve cardiospasm by hydrostatic dilatation usually results from lack of persistence on the part of the patient in swallowing a thread so that the dilator is not accurately introduced into the cardia or from inability to maintain proper position of the dilator in the cardia during inflation.

#### DIFFUSE SPASM OF THE ESOPHAGUS AND SPASM AT THE CARDIA

The symptoms of diffuse spasm of the esophagus may be indistinguishable from cardiospasm, but roentgenoscopic study will usually be sufficient for differentiation. In cases of diffuse spasm the lower half

of the esophagus presents evidence of excessive spastic contraction on roentgenoscopic examination, and on esophagoscopy examination the lumen of the esophagus may appear almost obliterated. Dilating sounds may be passed through the esophagus, but usually enough resistance is encountered to require a moderate degree of pressure before the sounds can be introduced into the stomach. Relief from dysphagia is less often obtained by dilatation in diffuse spasm than in cardiospasm.

One of my patients, who suffered from diffuse spasm of the lower half of the esophagus, required gastrostomy for feeding for eight years and then was spontaneously relieved from difficulty. During the activity of the spasm he was treated by medicines, esophagoscopy, hydrostatic dilatation of the cardia, passage of sounds, and bilateral cervicothoracic sympathetic ganglionectomy, all without beneficial effect. Two years after treatment was discontinued, symptoms disappeared as suddenly as they had appeared.

In the majority of cases of cardiospasm the disease is not associated with intra-thoracic or intra-abdominal lesions and is not dependent upon emotional factors for its origin or perpetuation. Diffuse spasm, however, may be associated with intra-abdominal lesions, and intermittent spasm at the cardia is frequently seen in patients who are nervously unstable.

Intermittent spasm at the cardia is seldom associated with significant symptoms other than epigastric pain and recurring obstruction of food at the cardia. Roentgenoscopic examination usually does not reveal evidence of obstruction at the cardia, but occasionally the passage of a sound will afford relief from symptoms.

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CYANOSIS may be defined as a bluish discoloration of the skin and visible mucous membranes. It may vary in tint from a deep purplish hue to a greyish slate color. It is due to the presence of an abnormal amount of reduced hemoglobin in the capillary blood.

# DIAGNOSIS OF INTESTINAL OBSTRUCTION\*

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THE increase in our knowledge concerning the pathological physiology and mechanical factors involved in patients with intestinal obstruction has changed many of the concepts of proper treatment for this condition. Such changes, however, have placed a premium on a more exact and detailed diagnosis of the individual case. No longer can the surgeon feel satisfied merely to make a diagnosis of "intestinal obstruction" and advise immediate laparotomy. The study of the case should include reasonable efforts to supply information on four additional points: (1) At approximately what point in the gastrointestinal tract the bowel is obstructed; (2) what degree of obstruction is present; (3) whether the obstruction is simple or strangulating in character, and (4) what pathological condition is responsible for the presence of the obstruction.

With proper diagnostic methods these refinements in diagnosis, especially the first three, can be achieved with considerable accuracy. Space will not permit a detailed discussion of the many lesions which may either primarily or secondarily be responsible for the obstruction. While the character of the lesion may be definitely determined in many instances, in others it can only be surmised on the basis of probability.

The importance of an accurate detailed diagnosis can be most appreciated by realizing that the best interests of the patient are not necessarily served by an immediate operation. Only those patients in whom the obstruction is strangulating in character or in whom there is a complete obstruction of the colon demand immediate surgical intervention. Other patients can be satisfactorily controlled for a matter of

hours or days, by means of constant suction applied to an indwelling tube, such as the Wangenstein type of Levin duodenal tube or the Miller-Abbott tube. The time thus gained during which the physiological status of the patient can be restored to near normal by the parenteral injection of saline and glucose solutions or the administration of blood transfusions will be appreciated by all surgeons of experience. Such treatment carried out in the preoperative period definitely decreases the risks of operation and has been one of the factors contributing to the lower mortality rates now appearing in the literature. Operation may even be avoided in an appreciable number of patients treated by conservative means. It is of the utmost importance, however, that operation be withheld even temporarily only from those patients in whom there is no complete obstruction of the colon or strangulation of the bowel.

## BASIS OF A DIAGNOSIS

The making of any diagnosis is the result of rational mental processes by which an opinion is formulated on the basis of collected evidence. In general, it can be said that such evidence is collected from three sources as follows: (1) The medical history; (2) the physical examination, and (3) the results of special diagnostic procedures: (a) laboratory examinations and (b) x-ray examinations.

*Medical History.* The importance of a complete knowledge of a carefully taken history in making a diagnosis of intestinal obstruction can not be overemphasized. It may serve only to confirm a diagnosis which seems obvious from the gross physical findings, yet many cases occur in which the correct detailed diagnosis can be made

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only after the sequence of events as related by the patient or his attendants are appraised by the physician and integrated with other determined facts. Particular attention should be paid to the following points in the history:

*Age of the Patient.* Many lesions producing obstruction are suggested by the age of the patient. Meckel's diverticulum and malrotation of the gut are usually seen in children or young adults. Seventy-five per cent or more of cases of intussusception occur before two years of age. Obstruction of the colon which is usually due to a constricting carcinoma is rare before the age of forty.

*Nature and Extent of Previous Abdominal Operations.* Adhesions within the peritoneal cavity as a consequence of abdominal surgery account for such a large percentage of cases of obstruction that careful inquiry should always be made with respect to the patient's previous illnesses. Vidgoff found that 68 per cent of patients with obstruction in a series of 266 cases had had previous abdominal operations. Finney and Miller found that 50 per cent and 24 per cent, respectively, of the patients in their reported series had had a previous laparotomy. On the other hand, intestinal obstruction due to adhesions without a history of previous abdominal surgery is rare.

*Duration of the Present Illness.* Knowledge of this character is important for it permits the physical findings to be considered in their true significance.

*Character of Onset of Symptoms.* The manner in which the symptoms of intestinal obstruction make their appearance depends largely on the degree of obstruction present. Most cases of acute obstruction exhibit a sudden onset of abdominal symptoms. In cases with partial obstruction the onset of symptoms is more gradual and intermittent. Frequently, a partial obstruction of the colon due to a slowly growing carcinoma suddenly becomes complete. In these cases the intermittent slowly progressive symptoms of partial

occlusion become more severe and unremitting. The history usually given in these cases is characteristic.

*Character of the Abdominal Pain.* The pain of which patients with mechanical obstruction complain is cramp-like in nature with short intervals during which there may be little or no pain at all. These intervals vary from a few seconds to several minutes. If the obstruction is in the colon, the cramps tend to be less frequent than if the obstruction is in the small intestine. If strangulation is present in addition to obstruction, there is constant pain with exacerbations corresponding to the intestinal contractions.

This intermittent pain of obstruction is due to increased peristaltic activity of the bowel. These contractions are extremely severe at the beginning but with the passage of time as the gut becomes more distended it tends to lose some of its power of contraction so that within forty-eight or sixty hours the cramps become less severe and less frequent. At this stage, however, patients with a simple type of obstruction may experience a moderate degree of constant abdominal pain and soreness which may strongly suggest the presence of a strangulation. This discomfort is due to the peritoneal irritation produced by a plasma-like fluid which exudes from the obstructed part of the bowel.

*Frequency of Vomiting and Character of the Vomitus.* Vomiting, while one of the most characteristic symptoms of obstruction, may be entirely absent if the obstruction be in the colon. This is particularly true in those patients in whom the obstruction in the colon develops slowly. Furthermore, the vomitus in colonic obstructions is scanty in amount and never fecal in character. At most, the patient vomits small amounts of gastric and duodenal contents at infrequent intervals. On the other hand, in patients with obstruction of the small bowel, vomiting is frequent in occurrence and the vomitus copious in amount. The higher the point of obstruction the more severe is the vomiting.

Reverse peristalsis carries the contents of the bowel proximal from the point of obstruction up to the stomach so that soon after the onset of vomiting the vomitus assumes a fecal character as attested by its smell and appearance. With the passage of time as peristalsis becomes weaker and the patient dehydrated, vomiting becomes less severe and assumes a regurgitant character.

*Presence of Audible Intestinal Noises.* A history of audible intestinal noises associated with abdominal cramps can frequently be obtained in cases with obstruction of the small bowel. Such evidence, however, can only be considered as confirmatory of other diagnostic evidence and must be evaluated by the physician.

*Passage of Feces and Gas.* The passage of feces and gas after the onset of symptoms suggestive of intestinal obstruction does not necessarily exclude the diagnosis. It must be remembered that the bowel distal to the point of obstruction is normal, both anatomically and physiologically. It will continue its usual functions until it is empty. It can be said, however, that patients with a complete obstruction will not usually expel either feces or gas beyond twenty-four to thirty-six hours after the occurrence of the obstruction. Patients with a partial obstruction usually complain of constipation if the obstruction is in the colon. If the obstructing lesion is in the small bowel, there is usually constipation for a day or so at the time of the recurrent attacks of abdominal pain with normal defecation in the interval.

*Recent Loss of Weight and Strength.* A recent loss of weight and strength is usually complained of by patients with obstruction caused by a malignant growth. There are, of course, many other causes for loss of strength and weight, but these symptoms are always significant and should be carefully evaluated by the clinician.

#### PHYSICAL EXAMINATION

A careful physical examination is unquestionably the most important factor in determining whether or not the bowel is

obstructed. The history is only suggestive. In addition, the diagnosis of strangulation is dependent largely upon eliciting signs of peritoneal irritation by palpation. Physical examination is of less value in determining the degree of obstruction but the palpation of abnormal abdominal masses frequently furnishes the clue by which the character of the obstructing lesion can be surmised.

*General Examination.* The attention of the examining physician should be concentrated, for the most part, on the abdomen. Patients with simple bowel obstruction do not, as a rule, look particularly ill in the early stages of their illness. A slight elevation of the pulse rate and temperature may be present. Persistent vomiting, in time, will produce the signs of dehydration and circulatory collapse due to hypochloremia. Such patients have the external manifestations of deep surgical shock. Breathing is rapid and shallow. There is a generalized cyanosis and the skin is clammy with perspiration and cold. The blood chloride level will usually be below 450 mg. per cent.

If the obstruction be a strangulating type, the patient, as a rule, appears to be much more ill from the beginning of his illness. Alarming signs and symptoms of circulatory collapse develop much more rapidly than in patients with simple obstruction and from an entirely different reason. With strangulation the signs of collapse are due initially to the loss of blood into and out of the infarcted segment of gut, but as the bowel loses its viability bacteria and their toxins gain entrance into the peritoneal cavity and superimpose the consequences of a peritonitis. This loss of blood which occurs initially has virtually the same effect as an internal hemorrhage and is produced by the obstruction of the venous blood flow in the involved bowel. As the arterial circulation is rarely obstructed as much as the venous circulation, blood continues to be pumped into the infarcted bowel and escapes from the capillaries until thrombosis occurs. Therefore, it is evident that the severity and

rapidity of development of the initial systemic signs of strangulation tend to vary with the length of bowel involved. The peritonitis which develops in these cases may be localized or masked in certain instances. For example, in intussusception the infarcted intussusciens is sheathed by viable bowel and peritonitis is usually seen only in neglected cases. Strangulation occurring in an incarcerated hernia tends to produce a localized peritonitis at first. If these cases are neglected, however, the infection will spread and become general.

The general appearance and signs of a patient with a strangulation obstruction will be, therefore, those of shock. There is no need to enumerate them or the additional signs of peritonitis which appear later.

*Examination of the Abdomen: Inspection.* Abdominal distention has long been recognized as one of the cardinal signs of obstruction. This is due to the accumulation of gas and fluid in the bowel proximal to the point of obstruction. The degree of distention varies a great deal, being less in cases with lesions high in the jejunum and greatest in lesions of the ileum or colon. Minimal amounts of distention are very difficult to detect in obese individuals. In those cases in which the obstruction is in the transverse or ascending colon, the distention tends to be limited to the right side of the abdomen.

If the patient is not obese, the pressure of distended loops of bowel may give a corrugated appearance to the anterior abdominal wall and the movement of peristaltic waves along these corrugations may be detected from time to time. Such a picture always indicates that the obstruction is chronic in nature. Intestinal loops with normal muscular coats can never be seen. The hypertrophy of the muscle which comes with chronic obstruction must be present.

*Palpation.* Palpation of the abdomen should be performed with three things in mind: (1) Determine the presence of an abnormal mass; (2) determine the presence

of a hernia, and (3) determine whether or not peritoneal irritation is present.

The presence of any tumor should be detected if possible for these lesions are a frequent cause of obstruction. The tender mass produced by an intraperitoneal abscess may explain the etiology of an obstruction due to adhesions. The infarcted bowel of intussusception can not infrequently be felt if the patient can be made to co-operate. When it is realized that hernias by the incarceration of a segment of bowel are the most frequent cause of obstruction, the importance of a careful search for such lesions is self evident.

It is extremely important to determine the presence, extent and degree of any peritoneal irritation. On the basis of this part of the examination alone, the physician is often forced to decide whether or not strangulation is present. Tenderness, rebound tenderness and muscle spasm must all be carefully sought for and considered critically. Unless there is a satisfactory explanation of these findings on other grounds, their existence in a patient with obstruction must always be taken to indicate the presence of a strangulation. In the occasional patient, a moderate degree of peritoneal irritation will be found accompanying a simple type of obstruction. This is due to the transudation of a plasma-like fluid from the walls of the distended gut into the peritoneal cavity. A few patients, therefore, with simple obstruction may be subjected to operation under a mistaken diagnosis of strangulation. This fact, however, should not deter the surgeon from operating without delay in all cases in which the signs of peritoneal irritation are definite.

It has been observed at operation that a simple obstruction, due to an adhesion which is attached to the anterior abdominal wall, is frequently associated with some soreness and tenderness localized to the immediate area of attachment. In these cases, no other signs of peritoneal irritation are usually present. The symptoms are undoubtedly due to the tension of the

adhesion produced by the obstructed bowel.

*Auscultation.* The careful auscultation of the abdomen with the stethoscope is an essential part of the examination never to be omitted. The point to determine is whether or not borborygmi are heard coincident with occurrence of abdominal cramps.

If such a relationship can be established, the existence of intestinal colic is proved. The presence of intestinal colic is strong presumptive evidence that a mechanical obstruction is present. If enterocolitis, food allergy or some dietary indiscretion can be ruled out, the diagnosis of obstruction is not to be questioned. It should be noted, however, that paralytic (inhibitive) obstruction, such as is so universally seen after major abdominal surgery, exists without the close relationship of abdominal cramps and borborygmi noted above. No attempt has been made in this paper to include a discussion of this condition. As previously indicated, after the passage of time the peristaltic activity of the bowel becomes weaker so the borborygmi which may be heard are fainter. The same situation may obtain in cases of strangulation obstruction after peritonitis develops. It should likewise be born in mind that the borborygmi in cases of obstruction of the colon are much less prominent and less frequent than in cases of obstruction of the small bowel.

The auscultation of the abdomen for only a few seconds may be sufficient to determine the presence of intestinal colic, but not infrequently the interval between the abdominal cramps and borborygmi is prolonged. The examiner, therefore, should listen carefully for fifteen to twenty minutes before finally excluding the presence of colic. At times, the gentle massage of the abdomen or having the patient swallow a small amount of water will initiate the cramps and borborygmi.

It can not be said, as others have reported, that there is any characteristic quality of the borborygmi accompanying

intestinal obstruction. Many factors play a part in the production of these sounds. Among them are, strength of the peristaltic wave, the size of the distended loop of bowel and the relative amounts of gas and fluid which the bowel contains.

*Rectal and Vaginal Examination.* Examination by rectum and vagina is important to detect the presence of any masses within the pelvis which may either be the cause of the obstruction or produced by it. In simple obstruction of the small bowel, distended fluid-filled loops of intestine cannot infrequently be palpated by the examining finger. Strangulated blood-filled coils of gut, associated with a diffuse pelvic tenderness, can be perceived more definitely. A carcinoma of the rectum causing obstruction can often be directly palpated. In cases with intussusception rectal examination may reveal the doughnut-like intussusciens as an intracolonic mass. In other cases with the same condition, though no mass may be felt, blood can be seen on the examining finger.

#### SPECIAL DIAGNOSTIC PROCEDURES

*Laboratory Procedures.* The existence of a simple type of obstruction *per se* produces no characteristic changes detectable by the commonly employed laboratory procedures. If vomiting has been persistent to the point of definite dehydration changes in the blood associated with hemoconcentration, hypochloremia and extrarenal uremia will be found. The hemoglobin concentration, the red blood cell count and the white blood cell count will be elevated. The blood urea nitrogen content and the carbon dioxide combining power of the blood will be increased. The chloride concentration in the blood plasma will be decreased. The urine may or may not show a slight amount of albumin and a few hyaline casts.

The laboratory findings of strangulation obstruction are the result of three factors: dehydration from vomiting, loss of blood from internal bleeding and the development of peritonitis. The elevated white



blood cell count and relative increase in the number of polymorphonuclear leucocytes are the most consistent changes found.

*X-ray Examination.* The use of the x-ray in the diagnosis of intestinal obstruction has become a routine procedure in most surgical clinics. In no instance should a diagnosis be made on the x-ray examination alone, but as a means of confirming the results of a physical examination and as a means of excluding other possible diagnoses, roentgenological examination is unexcelled.

The most valuable film is the so-called "scout film" of the abdomen taken with the patient lying prone. The obstructed loops of bowel on such a film are indicated by the quantities of gas which they contain. Because of the distance between the bowel and the film, these gas shadows appear on the film magnified approximately 25 per cent. Some clinicians have advocated taking the film with the patient lying prone and others with the patient sitting upright or standing. In the prone position, the gas shadows form a bizarre pattern due to the displacement of the intestinal loops by pressure of the vertebral column. In the upright position, multiple fluid levels seen scattered throughout the abdomen are found in the presence of obstruction. Neither of these positions gives as comprehensive or as valuable information as a film taken in the supine position.

The information to be sought from the x-ray film is concerned with the amount and position of accumulations of gas in the gastrointestinal tract. Normally, gas can be visualized in the small intestine only in infants and small children. The reason for this fact is not clear. Adults and children alike, however, exhibit normally, accumulations of gas in the colon. If there is stasis of the contents of the small intestine, the contained gas and fecal content separate out and the gas is seen as discrete shadows on the film. The visualization of gas contained within the small bowel, therefore, may be taken to mean obstruction in the broadest sense of the term.

The gas accumulations in the small intestine assume characteristic patterns depending upon the portion of bowel involved. The distended ileum appears as an almost smooth tube. The jejunum shows a feathery outline due to the very prominent plicae circulares. Gas shadows in the colon appear coarsely scalloped, due to the haustrations. Familiarity with these patterns and a careful study of the x-ray film usually permits an accurate estimation of the site of the obstruction to be made.

The presence of loops of distended small bowel with little or no gas in the colon indicates that the obstruction is probably complete and in the small bowel. The restriction of the visible gas to the colon is the usual pattern found with acute obstructions of the colon. In about 25 per cent of such cases, however, the ileocecal valve is incompetent and allows gas from the colon to pass into the small bowel. In these cases, therefore, the terminal ileum may be distended as well as the colon. Partial obstructions of the small bowel, if at all severe, will exhibit some distention of the proximal bowel with small scattered accumulations in the colon. If the obstruction is in the colon, the visible gas is confined to the colon almost entirely and this is not great in amount. The gas seen on the x-ray film of a patient with paralytic (inhibitive) ileus may on occasion simulate closely the gas patterns of any type of obstruction. In the usual case, however, stasis of fluid and gas occurs in both the colon and small bowel. The size of these accumulations depends on the duration and severity of the ileus as well as the quantity of air which the patient swallows.

#### DIFFERENTIAL DIAGNOSIS

The diagnosis of a typical acute mechanical small bowel obstruction is not difficult. Recurrent crampy abdominal pain associated with increased borborygmi and vomiting if confirmed by an x-ray examination can leave little doubt. Occasionally, other abdominal colics must be excluded. This differentiation is best made with the

stethoscope and careful auscultation of the abdomen. An acute gastroenteritis sometimes closely simulates an early acute obstruction. However, the vomiting associated with gastroenteritis ceases to be productive when the stomach and duodenal contents have once been removed. Furthermore, diarrhea is usually a prominent symptom of gastroenteritis.

The diagnosis of chronic small bowel obstruction rests largely on the basis of a history of previous attacks and the presence of intestinal colic. The x-ray aids in the diagnosis by furnishing for most part "negative" evidence. This type of information, however, is frequently of major importance in arriving at many diagnoses and should not be disregarded.

The existence of peritoneal irritation in a patient with suspected obstruction immediately brings up the question of strangulation. The chief differentiation must be made between strangulation obstruction and inflammatory lesions such as acute appendicitis, acute salpingitis and twisted ovarian cyst. A careful clinical history, pelvic examination and x-ray studies of the abdomen are most helpful.

The most difficult decision which the physician has to make in dealing with obstruction is to recognize a strangulation obstruction which develops on the basis of a simple obstruction due to adhesions produced by an acute inflammatory process. Fortunately, this problem does not frequently arise. One can hardly say that all patients with acute obstruction and signs of peritoneal inflammation should be operated upon. Simple obstructions can be adequately controlled usually for days without operation and patients with definite peritonitis are in the main best treated by conservative methods. However, the price to be paid by neglecting to operate upon a strangulation obstruction is so great that in cases in which such a diagnosis cannot be reasonably excluded, the lesser of two evils would seem to be an exploratory laparotomy. A rapid increase in the sever-

ity of abdominal pain and tenderness associated with a concomitant elevation of the pulse rate usually attends the onset of strangulation.

If any doubt remains as to the presence of an obstruction of the colon after consideration of the history and physical examination, the x-ray film usually settles the issue. A word of caution is in order concerning obstructions located in the cecum and ascending colon. A competent ileocecal sphincter produces a short, closed loop in these cases which may become distended and even rupture without producing alarming symptoms. Since the distended loop is so short, no clinical distention may be detected even on the x-ray film, and unless the possibility of such a lesion is borne in mind, the significance of the distended segment may be discounted. Crampy pain with tenderness in the right lower quadrant of the abdomen with or without the presence of a palpable mass in this area should suggest the diagnosis.

Strangulation obstruction involving the colon is almost always due to a volvulus of the sigmoid flexure. Usually these cases exhibit an unusual amount of abdominal distention. Signs of peritoneal irritation will be dependent upon the degree of vascular occlusion occasioned by the twist of the bowel. Many cases give a history of previous subacute attacks. Frequently the pattern of the gas shadows on the x-ray film suggests the diagnosis. Fluoroscopic examination and administration of barium by rectum will confirm the diagnosis in a suspected case.

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# CARCINOMA OF THE STOMACH\*

## DIAGNOSTIC ASPECTS

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THE diagnosis of carcinoma of the stomach during the stage in which it is amenable to surgical treatment still presents a serious problem to the clinician, surgeon and radiologist. The principal reason for this difficulty lies in the fact that in the early stages of the disease appreciable symptoms may be lacking, or if they exist, present anything but a definite and clear-cut clinical and radiologic picture. The essence of the problem at the moment, therefore, is to entertain the diagnosis of this disease on suspicion and when such suspicion has been aroused to command every possible clinical, radiological, gastroscopic and even surgical facility to establish its diagnosis. This means that in addition to examination by these methods consideration must be given to careful observation of the clinical course of the patient under suspicion and at times to surgical exploration of the stomach when a lesion of undetermined nature is found to exist within it.

Reasons for emphasizing these points are well brought out in the recent review by Gray, Walters and Priestley on the operability and resectability of carcinoma of the stomach. In their experience at the Mayo Clinic in 40 to 50 per cent of cases the lesion is an inoperable one when it is found on clinical examination and in half of the cases in which operation is performed the malignant process will have progressed to such a degree that nothing of a curative nature can be effected. Furthermore, figures on the resectability of carcinoma of the stomach have shown surprisingly little

change over a period of fifteen years according to these observers. It is pointed out that the percentage of patients who underwent resection of the stomach as compared to the total number of patients who had gastric carcinoma has remained consistently near 30 per cent during this period (1926 to 1940).

In any consideration of the diagnosis of carcinoma of the stomach consideration must be given briefly to such problems as the incidence of the disease and the pathologic anatomy of it, for these phases of the problem give to the clinician an orientation which more readily sets him on his diagnostic path.

### INCIDENCE

Carcinoma occurs more commonly in the stomach than in any other organ. Eusterman<sup>3</sup> has pointed out that practically 40,000 persons in the United States die every year from this disease. This figure corresponds quite closely with that for the number of persons killed annually in the country by automobile accidents. The disease occurs in men two or three times as frequently as it does in women, and the average age of occurrence is fifty-three years. Approximately 95 per cent of patients with carcinoma of the stomach fall in the age group between forty and seventy, while 5 per cent are less than forty years of age.

### PATHOLOGIC ANATOMY

It generally is recognized that there are several pathologic types of carcinoma of

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the stomach and that the disease may occur in any portion of the stomach. The symptoms with which the disease manifests itself depend to a considerable extent on the type of lesion present, the duration of it, and probably even more on the location of the lesion in the stomach. One type is the fairly well localized tumor which proliferates into the lumen and wall of the stomach forming the well known papillary, medullary or cauliflower-type of growth. Such a lesion involving the pyloric end of the stomach may first manifest itself by symptoms of pyloric obstruction and gastric retention and these phenomena may occur while the lesion is still a small one. When this type of lesion occurs in the fundus and especially on its anterior, posterior or greater curvature aspects, it frequently may be silent clinically except for the development of symptoms referable to anemia and cachexia.

Another type of lesion is that represented by diffuse infiltration of a part of or all of the wall of the stomach. This so-called scirrhus or linitis plastica-type of the lesion is the most common form, it is the most difficult to cure and in its clinical manifestation various types of dyspepsia, anorexia and at times obstruction of the pylorus commonly occur. Finally carcinoma, which appears roentgenologically in the form of ulcerous lesions, may pathologically in gross form simulate benign peptic ulcer. Symptoms associated with such lesions not infrequently resemble those of "ulcer-type of dyspepsia" and penetration of the lesion or gross bleeding from it occur also.

Another point of considerable interest in the pathologic anatomy of this lesion is in relation to its pathogenesis, particularly as it relates to the previously existing state of the gastric mucosa. Many clinicians are of the opinion that carcinoma rarely if ever develops in a gastric mucosa which is normal. The rôle of gastritis and particularly atrophic gastritis as a predisposing factor in the development of gastric carcinoma is widely but not universally accepted.

#### CLINICAL SIGNS AND SYMPTOMS

Many physicians think of carcinoma of the stomach in terms of the far advanced picture of the disease. From the standpoint of effective treatment it is too late to make the diagnosis when the patient presents persistent indigestion, coffee-ground vomitus, marked anemia and loss of weight, a large palpable abdominal mass and signs of pyloric obstruction. The clinician must be taught to realize that he should attempt to make the diagnosis of carcinoma when only the vaguest symptoms are present if he is substantially to reduce the mortality rate. Any person, and especially one over the age of thirty five, in whom symptoms of indigestion persist over a few weeks without known cause is entitled to a thorough investigation of his gastrointestinal tract. Too often under these circumstances the physician treats the patient symptomatically for a period of months before it becomes apparent that a carefully planned gastrointestinal study should be carried out. Moreover, not infrequently such symptomatic therapy affords the patient temporary relief while an unsuspected cancer silently proliferates. Later when the lesion is found it often is too late to carry out any operative procedure which will afford a permanent cure.

As Bloomfield has pointed out, it is really useless to try to give any composite description of the symptoms of gastric cancer since they are so variable and not infrequently by the time the very first symptom may manifest itself, roentgenologic study may reveal the presence of a large, proliferating tumor which is beyond the hope of resection. However, there are certain characteristic ways in which the symptoms may begin. As previously pointed out (Wilbur) the modes of onset of symptoms of carcinoma of the stomach depend in a large part on the pathologic type and situation of the lesion and to some extent on the reactivity of the individual; that is, whether he is hypersensitive or hyposensitive. Lesions which exist near the pylorus will more likely lead to ob-

struction, whereas those high in the fundus of the stomach will more often produce anemia, loss of weight and strength and vague dyspepsia.

Associated with the most common mode of onset of the disease is the so-called typical history. The characteristics of this typical history are as follows: the patient, usually middle-aged, gives a life long story of perfect digestion until the gradual or rapid onset of persistent dyspepsia, which is characterized by anorexia, fullness and discomfort after meals, belching, burning, nausea and occasionally by vomiting with loss of weight and strength. The story usually is a progressive one, and not infrequently the patient is somewhat emaciated and on rare occasions accompanies his story with the statement that he may palpate an abdominal mass. Not infrequently these symptoms begin following a brief period of illness characterized by the patient as an attack of the "flu."

Carcinoma of the stomach may begin with symptoms like those of peptic ulcer. The symptoms may be of long or short duration, but it should be pointed out that this does not mean that the carcinoma developed in a benign ulcer. The occurrence of symptoms suggesting ulcer may mislead one from the correct diagnosis. According to Eusterman and Kirklin about a fourth of resectable carcinomas of the stomach simulate peptic ulcer, especially at the onset. When a patient past middle age presents a history of ulcer type of dyspepsia of short duration one should be on the look-out for carcinoma. Similarly, suspicion should be aroused if there is loss of weight and strength out of proportion to the reduction of intake of food. When the history with ulcer characteristics is of long duration one should suspect the development of a complication, of associated disease, or of carcinoma, particularly if there occur (1) disappearance of intermittency of exacerbation of symptoms with substitution of a continuous or remittent clinical course, (2) irregularity, diminution, or disappearance of pain-food-ease sequence, (3)

substitution of the usual distress by a dull ache, more or less continuous, and aggravation rather than ease by alimentation, and (4) nausea and anorexia. In addition, if carcinoma of the stomach is present the following objective phenomena may be found: (1) lowered gastric acidity, (2) anemia without gross bleeding, (3) occult blood in the gastric contents, and (4) disturbances in motor function of the stomach (Eusterman).<sup>3</sup>

Carcinoma of the scirrhus or polypoid type occurring near the pylorus may produce pyloric obstruction early or late in the course of the disease. When symptoms of obstruction arise early, and especially when they are associated with a previous history of ulcer, diagnosis may be difficult if not impossible. One may have to be content with the diagnosis of obstruction at the outlet of the stomach. As Eusterman<sup>3</sup> has pointed out, gastric retention may occur in cases of carcinoma of the stomach without a lesion at the pylorus, and one should think of this diagnosis when there is a residuum in the fasting stomach if barium is not retained after six hours. In addition, he has pointed out that in 60 per cent of cases in which the lesion is resectable and in 40 per cent of cases in which the lesion is small gastric retention is present.

Anemia is one of the commonest findings in malignant disease. This is particularly true of malignant disease of the gastrointestinal tract, and anemia at times is the first and presenting symptom of carcinoma of the stomach. The anemia usually depends on the presence of an ulcerating or polypoid lesion. If this lesion is in such a position in the stomach as not to interfere with its emptying, anemia may be present before any other symptom develops. The anemia usually depends on bleeding, which is the result of ulceration into vessels or of necrosis and sloughing of small vessels in the growth. It may be sustained in part by poor nutrition of the individual because of the carcinoma, or it may possibly result from a disturbance in the metabolism of hematopoietic substances (intrinsic factor

or pernicious anemia). Carcinoma of the stomach rarely produces gross bleeding except as a terminal phenomenon. In only 1 per cent of cases does it lead to gross hematemesis (Rivers and Wilbur).

Patients who present themselves because of a general decline in health or because of a general weight loss and strength not infrequently have carcinoma of the stomach even though gastrointestinal symptoms are absent. Not uncommonly symptoms may begin with an illness interpreted by the patient as an acute infection of "the flu." Anorexia may be the only symptom, or pallor and weakness alone may be present. It is important to recall that carcinoma of the stomach may develop in the presence of any chronic disease. In the presence of these clinical symptoms the carcinoma is not infrequently situated in the fundus or cardiac portion of the stomach, where it may be difficult to find roentgenologically. Occasionally, specific nutritional disturbances will occur as a result of carcinoma of the stomach. Eusterman and O'Leary have emphasized the development of pellagra in association with gastrointestinal disease, particularly those producing obstruction.

Rarely will the outstanding symptoms presented by a patient with carcinoma of the stomach be the result of metastasis. Metastasis generally does not occur early, but occasionally it may be extensive when the original lesion is small. The usual sites of metastasis, the liver, regional lymph-nodes, peritoneum, pancreas, pleura and lungs are not commonly involved early enough to provoke symptoms before those produced by the initial lesion. If metastasis produces the presenting symptoms, the lesion in the stomach is most likely in a "silent spot" and the metastasis involves a very important organ such as the brain, spinal column or bone marrow.

*Physical examination* of the patient suspected of having early carcinoma of the stomach generally is not very helpful in establishing the diagnosis. However, unexplained pallor or pasty color, obvious emaciation, or any change in the general

appearance of the patient from that of previous good health are suggestive signs. Occasionally, there may be slight tenderness in the epigastrium on palpation; usually a mass is not palpable. When the disease becomes more advanced evidences of pallor, weight loss, ascites and abdominal masses may appear. In all instances the physician should remain constantly on the lookout for evidence of metastasis in the left supraclavicular region, on the rectal shelf and occasionally at the umbilicus.

Ordinary *laboratory procedures* generally are not very helpful in pointing the way to the diagnosis in early stages of the disease. Examination of the blood may, of course, provide evidence of anemia, but frequently the results are normal. Analysis of the gastric content may be helpful in establishing the presence of gastric retention which should lead to further careful investigation, and it may, after stimulation with histamine, reveal a secretion which is less than the normal in volume and acid content. The large number of reports on the character of the gastric secretion in carcinoma of the stomach may be summarized by saying that in general in this disease there is a tendency for the volume of gastric secretion to be low and for the acid content of it to be low or absent. However, in over 50 per cent of cases of early lesions free hydrochloric acid may be present in the gastric content and in some patients with extensive carcinoma of the stomach the volume and concentration of acid may be exceedingly high and resemble those of benign ulcer. While statistical studies of this problem show definite trends in one direction or another, the important clinical point is that such studies fall down completely when an attempt is made to put them to diagnostic use in an individual case. It seems reasonable to conclude that when achlorhydria is found further studies by roentgenologic and gastroscopic methods are imperative.

Examination of the stool for occult blood and observation of blood in the gastric content may be of considerable interest, but generally the results of such examina-

tions are not of great diagnostic importance unless they repeatedly are positive under conditions of careful control of a meat free diet and in the proved absence of other lesions.

#### ROENTGENOLOGIC DIAGNOSIS

The most reliable widely available diagnostic procedure in the clinical diagnosis of cancer of the stomach is roentgenologic examination of the stomach. In the hands of the skilled roentgenologist this method of examination has rapidly become a highly satisfactory and accurate one, and is in fact worth more than that of all other laboratory methods combined because it is a direct method of examination, it permits visualization of the gastric outline and of the peristaltic and motor activity of the stomach which are invaluable in determining the condition of the organ. The radiologic features of gastric carcinoma are well known and it is not the purpose of this clinical discussion to undertake a prolonged discussion of the characteristic diagnostic aspects of these lesions. In brief, the presence of persistent filling defects, of areas of thickening of the gastric wall with associated rigidity and absence of peristaltic activity, of large and often fixed ulcerating lesions, and of smaller ulcerating lesions especially if they are located on the greater curvature and occur near the pylorus—all are indicative of gastric neoplasm. Roentgenologic examination is of value also not only in detecting the presence of a lesion but it also gives the physician a knowledge of the location of the lesion in the stomach. One of the most commonly debated problems among radiologists and clinicians has to do with the benign or malignant nature of an ulcerating lesion. Experienced radiologists become very skilled in differentiating between such lesions by observations of the size and location of them, the shape and depth of them, the presence or absence of tenderness and associated spasm, and the observation of Carman's meniscus sign. However, the radiologist is not always able to characterize the nature of an ulcerating

lesion, and in such cases it is necessary to depend on the subsequent clinical course of the lesion, on gastroscopic observations or on surgical exploration.

Perhaps of greatest importance in considering this subject is that of knowing when to demand roentgenologic examination. No arbitrary rule can be established in regard to the advisability of making x-ray studies but it is a good clinical rule to do so when the patient presents symptoms of persisting dyspepsia or those previously noted in the paragraphs on modes of onset of symptoms of the disease. In other words, the examination must be made more on clinical suspicion of the disease in the future if earlier lesions are to be observed. Moreover, if the study is negative and the patient's symptoms persist, further examination should be carried out in four to six weeks.

#### GASTROSCOPIC EXAMINATION

In recent years observations of the stomach through the gastroscope have provided an additional useful means of diagnosing carcinoma of the stomach. The usefulness of this procedure depends almost entirely on the experience of the gastroscopist, not only in his previous observations of lesions, but also in the correlation of his gastroscopic observations with those of the same lesions at the operating table or by the pathologist. Gastroscopic examination may confirm the roentgenologic diagnosis of the carcinoma and not infrequently it may provide definite evidence of the benign or malignant nature of a lesion subject to questionable roentgenologic interpretation. Occasionally, the gastroscopist is able to see a lesion which is suspected clinically but which for various reasons may be overlooked by the radiologist. Polypoid tumors generally are easily distinguished while ulcerating lesions present a less certain diagnostic problem. The carcinomatous character of a lesion may be suspected when the edges of it are heaped up and fade gradually into the normal gastric mucosa, when the edges of the

lesion are somewhat irregular and the floor of it is covered with necrotic tissue and exudate dirty gray, brown or red in color.

Schindler points out that the importance of gastroscopy in the early diagnosis of gastric carcinoma has been disputed although many gastroscopists recognize its value in the differential diagnosis of benign and malignant lesions and in the determination of operability. He further adds that the early diagnosis may be possible if each patient over thirty-five years of age who suffers from mild digestive symptoms or loss of weight otherwise unexplained is examined roentgenologically and gastroscopically without delay. Gastroscopy may be helpful in the determination of the operability of gastric carcinoma for the extent of the lesion may be more apparent than it is on roentgenologic study.

Schindler follows Borrmann's classification of gastric carcinoma, which is composed of four main types: Type I, polypoid carcinoma, is a sharply limited, operable lesion and carries an excellent prognosis. It was observed by him gastroscopically in 2.9 per cent of carcinomas. Type II, non-infiltrating carcinomatous ulcer, is a lesion which is surrounded by a sharply limited wall and carries a good prognosis. It was found in 17.6 per cent of carcinomas observed by Schindler. Type III, infiltrative carcinomatous ulcer, is a tumor only partially surrounded by a limiting wall, and even if operable the prognosis is still doubtful. This type of lesion occurred in 16.3 per cent of carcinomas. Type IV, diffuse infiltrating carcinoma, need not be extensively ulcerated. It almost always gives a bad prognosis, and even if resectable goes on to early recurrence and metastases. It occurred in 63.2 per cent of the carcinomas observed by Schindler. The gastroscopic picture has been found more characteristic than that of the gross specimen at times, on account of the presence of circulating blood. However, Schindler emphasizes the point that gastroscopy and roentgen-ray examination are not competitive, but that each supplements the other.

#### CLINICAL COURSE

In an occasional patient, and particularly in that group of patients presenting an ulcer in the stomach, it may be advisable and necessary to follow by close observation the clinical course of the patient and his lesion. The old discussion of whether or not a benign gastric ulcer will become malignant and, therefore, should be surgically removed is of no value whatever in considering the problem presented by an individual patient with such an ulcerating lesion. The important point to consider at the time the patient is observed is whether or not the lesion is malignant. There are only two ways in which the differentiation can be made. The first is to wait and see what happens and if the patient later develops symptoms of extensive cancer of the stomach one can be reasonably sure that at the time of initial examination the lesion was a malignant one. This method obviously is impractical. The second method is to excise the lesion and study it under the microscope for evidence of carcinoma. The gastroscopist would surely add that his method of examination should be included as a third method by which such differentiation can be made. In the hands of the expert gastroscopist this occasionally can be done but there is no gastroscopist whose opinion in this regard is infallible.

From the practical point of view it is not reasonable to operate immediately upon every patient with an ulcer in the stomach; nor is it advisable to ignore the clinical course of such lesions until a later time when it is obvious that the lesion is a benign or a malignant one. The obvious answer is carefully to watch the course of the lesion under medical treatment. This should be done by clinical, radiologic, and when possible gastroscopic means. In a recent review of the subject Eusterman<sup>2</sup> points out that insufficient stress has been placed in the differential diagnosis of carcinomatous and benign ulcerations on the diagnostic significance of the response to medical treatment.



Gradually, however, physicians are accepting the viewpoint that the degree of demonstrable anatomic change in an ulcer undergoing treatment is of as much or greater significance as symptomatic improvement. The importance of this viewpoint is in the fact that the symptoms arising from gastric cancer of all types may be relieved considerably in a large number of patients, but that generally anatomic improvement in the lesion indicates its benign character while failure to heal is indicative of a malignant process. This viewpoint cannot be completely accepted.

The failure of a lesion to heal under medical treatment is not indicative that it is malignant and the apparent healing of the lesion is not proof of its benign character. It is quite true that the majority of benign gastric ulcers will decrease in size or heal on medical treatment and that the large majority of carcinomatous ulcers or ulcerating carcinomas will decrease little in size, if at all, under the influence of medical treatment. Exceptions exist. Another confusing factor is that in recent years the gastroscopist has produced evidence that an ulcer still may be active and unhealed even though there is complete disappearance of the niche from a roentgenologic point of view. And to add further confusion to the general picture, Eusterman<sup>2</sup> recently has reported five cases in which gastric carcinoma not only masqueraded as benign ulcer but reacted to treatment in a similar fashion as well.

Under circumstances of this almost completely bewildering set of observations, what is the average practising physician to do in the handling of his patient with a suspicious looking ulcerating gastric lesion? Eusterman<sup>2</sup> is of the opinion that suspicion of cancer is justified under the following circumstances: "location of the lesion in the prepyloric first inch, posterior wall or greater curvature, large size, consistent achlorhydria after stimulation with histamine, persistent or frequent recurrence of occult blood in the feces during treatment, late onset in an elderly person and reduced

gastric acidity and secretory volume estimated under basal conditions, especially in association with early pyloric obstruction." If these symptoms or findings exist then great care must be given if the patient is placed on medical treatment and the criteria so well formulated by Jordan should be followed. These criteria are that while under careful medical treatment there shall be complete disappearance (1) of occult blood from the stool; (2) of radiologic signs of the defect and (3) of all symptoms. To this she now adds a further criterion that the lesion must not recur under treatment. In this connection the importance of gastroscopic observation of a lesion under treatment is very desirable. Taylor on the basis of repeated gastroscopic observations has well stated the value of this procedure when he expressed the opinion that failure of an ulcer to change at all after three weeks of intensive treatment in the hospital is sufficient evidence that it is malignant. Perhaps the statement should be modified and stated as a clinical rule that in the case of such a lesion surgical exploration is justified and in fact demanded on the strong presumption that the lesion is a malignant one.

For those clinicians who do not have an experienced gastroscopist available and perhaps for those who do, the advice of Eusterman<sup>2</sup> is well taken in considering the clinical course of an ulcerating gastric lesion. He states that all such patients "submitted to treatment should undergo routine examination at intervals of three months for at least a year and at intervals of six months thereafter for an additional period of twelve to eighteen months." Such examination should certainly include roentgenologic observations.

#### SURGICAL EXPLORATION

In the early diagnosis of carcinoma of the stomach, surgical exploration must be considered an important method of diagnosis in some cases. As already pointed out in recent years, despite all the refinements of old and the developments of new

methods of examination of the stomach, in the experience of surgeons<sup>6</sup> at the Mayo Clinic the percentage of patients who underwent resection of the stomach to the total number of patients who had gastric carcinoma has remained consistently near 30 per cent for fifteen years (1926 to 1940). It seems reasonable to conclude among other things that surgeons of a previous day were as successful as we are now in "spotting" such lesions not because they often made the clinical diagnosis preoperatively but because they operated often on the basis of suspicion of the character of the lesion and because they operated more often than is being done now on patients with "gastric ulcers."

It still is good advice seriously to consider exploration for patients who have gastric lesions of unexplained nature, particularly when there is available a surgeon with experience in dealing with this type of lesion.

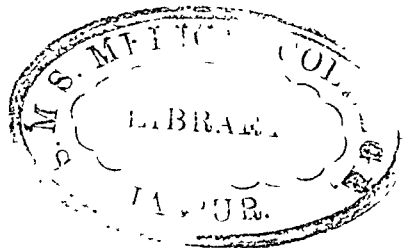
#### SUMMARY

If the results of surgical therapy of carcinoma of the stomach are to be effectively improved in the next few years, the diagnosis of the lesion will have to be made earlier. The essence of this problem at the moment is to entertain the diagnosis of the disease on suspicion and when suspicion exists to command every possible clinical,

radiological, gastroscopic and even surgical facility to establish the diagnosis. If no more than suspicion of the nature of the lesion exists but the suspicion for good reason persists, the stomach should be explored surgically.

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# COMPLICATIONS ASSOCIATED WITH APPENDICITIS\*

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IN a discussion of postoperative complications Cutler and Scott<sup>1</sup> state that, "With the period that follows operative intervention begin the trials and tribulations of the surgeon." This statement is probably nowhere more true than in the case of those patients who require surgical attention because of a septic appendix, and in whom infection has extended beyond the confines of this organ. It is a well known fact that today the mortality of appendectomy for uncomplicated acute appendicitis is almost negligible, whereas in the more advanced cases, when peritonitis of some degree has supervened, the mortality continues to be disturbingly high. For the most part, deaths from acute appendicitis are due to some phase of peritonitis either directly, as from toxemia, severe sepsis and ileus, or indirectly from the later complications of peritonitis, e.g., intestinal obstruction, empyema, pneumonia, etc. If one consults the records of the surgical clinic in any large hospital, the more serious complications of acute appendicitis will be found to include general peritonitis, residual or secondary abscesses, intestinal obstruction, major wound sepsis, pneumonia, pylephlebitis, liver abscess, empyema, pulmonary embolism, fecal fistula, postoperative hemorrhage and thrombophlebitis. The present discussion is concerned with the abdominal complications encountered in the management of the perforated appendix and, in particular, with those which occur following operative intervention.

## GENERAL PERITONITIS

Diffuse peritonitis is most often the result of sudden perforation in the obstructive type of acute appendicitis which,

according to Allen,<sup>2</sup> is responsible for 95 per cent of the deaths from this disease. The obstruction of the appendix is usually due to a fecalith. The process advances rapidly due to interference with the blood supply of the appendix and consequent necrosis of its wall. Perforation may occur as early as four hours following the onset of symptoms. Due to the sudden flooding of the unprepared peritoneum with septic material, little opportunity is afforded for the usual walling-off process to take place and a diffuse or general peritonitis ensues. Coller and Potter<sup>3</sup> found eighty-eight cases of general peritonitis among 336 patients with acute appendicitis, in all stages of the disease, admitted to the University of Michigan Hospital over a three-year period, an incidence of 22.2 per cent. Stafford and Sprong<sup>4</sup> found 196 instances of general peritonitis in a similar group of 1,317 patients admitted to the Johns Hopkins Hospital over an eight-year period. The incidence of peritonitis in this group was, therefore, 14.9 per cent. Barrow and Ochsner<sup>5</sup> found 179 cases of general peritonitis in a group of 1,039 cases of acute appendicitis admitted to the Charity Hospital in New Orleans, an incidence of 17 per cent. The diagnosis of acute appendicitis with general peritonitis is not difficult. The patient complains of severe generalized abdominal pain, with nausea and vomiting. The abdomen becomes distended, tense and rigid. There is tenderness throughout, although it remains more marked in the right lower quadrant. Auscultation reveals a silent abdomen. The temperature is considerably higher (101°F.) than in uncomplicated acute appendicitis, and the pulse rate is increased accordingly. The leucocyte count is also

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high, e.g., 25,000 to 30,000. If the infection continues unchecked, the unmistakable picture of a terminal peritonitis develops. The pulse becomes rapid and thready, there is profuse diaphoresis, the skin is cold and clammy, abdominal distention is marked, the eyes are sunken, the expression is anxious and there is pallor and cyanosis, signs which denote impending death. It goes without saying that the most important treatment is prophylactic, i.e., recognition of the disease and removal of the appendix before infection has spread beyond this viscus. The management of the patient with general peritonitis remains a controversial matter. Many authors, (Horsley,<sup>6</sup> Herrick,<sup>7</sup> Davis, Stafford and Sprong<sup>8</sup> and others), advise prompt operation regardless of the stage of the disease. It is our opinion that these patients with widespread or general peritonitis are best treated by delayed operation and we recommend the Ochsner regimen in order to improve the patient's general condition and to allow localization of the infection to take place before any operative procedure is performed. However, we agree with Allen and his associates that if one sees these patients within four to six hours from the time of perforation, prompt operation is best. By means of a careful history, very often the time of perforation can be determined. There is often an acute increase in the severity of the pain followed by a period of temporary relief. In such instances, while there is soiling of the regional peritoneum and perhaps an early local peritonitis, the peritoneum is capable of handling this limited amount of infection, provided further contamination is prevented by removal of the appendix. Moreover, protective adhesions have not yet formed so that harm does not come from an operation in this stage.

As a postoperative complication, general peritonitis must be regarded as one of the most serious since the mortality is always high. From their study of the literature, Ochsner, Gage and Garside<sup>9</sup> concluded that peritonitis may be the cause of death in

as many as 77.5 per cent of patients dying of appendicitis. Fortunately, general peritonitis is not one of the common post-operative complications. When it does occur, it may be due (1) to contamination of the peritoneum by transperitoneal drainage of abscesses, (2) to failure on the part of the surgeon to drain when drainage is indicated at the time of the original operation, or (3) to an ill timed operation whereby early adhesion formation is interfered with; and what would be a localized infection if let alone, is converted into a spreading peritonitis. Occasionally, because of an especially virulent type of infection, general peritonitis will supervene regardless of the time and type of the original operative procedure. The subject of drainage is again a controversial matter. The present day trend is to drain less frequently than formerly, especially in cases in which a diffuse peritonitis is found at operation. However, the axiom, "When in doubt, don't drain," is capable of doing harm in the hands of young or inexperienced surgeons. Hanford<sup>10</sup> gives the following indications for drainage:

(1) Any appendiceal abscess. With this statement practically all authors agree. Drainage is also advised when tissue of doubtful viability must be left in the abdominal cavity, e.g., (a) necrotic tissue, such as part of the wall of an abscess; (b) part of the appendix; (c) the whole of the appendix; (d) damaged tissue, such as the meso-appendix stump, which might become necrotic in the presence of infection.

(2) In acute diffuse peritonitis with creamy purulent or fibrinopurulent exudate of considerable amount or with a malodorous exudate. Some authors would disagree with this statement.

(3) Insecure or doubtful closure of the cecum or the appendix stump.

(4) An unrecovered loose fecalith.

(5) Gross soiling by cecal contents.

(6) Infection or contamination of the retroperitoneal tissue as in a retrocecal appendix.

(7) Uncontrolled bleeding or doubt as to the control of bleeding.

As previously mentioned, general peritonitis may be the result of operative intervention which interferes with the walling-off of a local peritonitis following perforation. In the case of a slow perforation, as in the inflammatory type of appendicitis, the infection is efficiently localized if given a chance. In these slow perforations, the defensive mechanisms of the peritoneum come into play and prevent spread of the process by limiting the infection to the right lower quadrant or pelvis. Loops of intestine and the omentum become adherent to the cecum and appendix and adhesions quickly form. An abdominal mass may become palpable, although this need not be an abscess in the strict sense of this term. The process terminates by progressing to the stage of suppuration or, more often, by spontaneous resolution. Thus, in cases seen during the third, fourth or fifth day of the disease, with a mass present or in the stage of development, operation is best deferred. If performed during this so-called "danger period," Love<sup>11</sup> points out that protective adhesions are broken down and a spreading or general peritonitis may thus be provoked. Moreover, removal of the appendix under these circumstances presents technical difficulties and is attended with the danger of injury to the cecum or intestine. Excessive bleeding may be encountered and often the procedure is prolonged and an undue amount of trauma is inflicted. Simple drainage, on the other hand, is of little value and corresponds to attempts at incision and drainage of a superficial cellulitis while still in the stage of brawny induration. By delaying intervention until the proper time, extraperitoneal drainage of an abscess is possible or, in the case of spontaneous regression of the mass, a clean appendectomy may be performed at a later date.

Spreading peritonitis induced by or following operation may present a variable

clinical picture. In young and otherwise healthy adult patients, the usual picture of general peritonitis described above may be observed. However, in elderly persons or those weakened by their infection, fluid and salt imbalance or by a prolonged operation involving excessive trauma and hemorrhage, spreading or general peritonitis may exhibit a very atypical course. Here the usual signs of peritonitis are apt to be far less striking than usual. There is commonly some abdominal discomfort and distention, associated with absence of peristaltic sounds. Nausea and vomiting are common. The temperature may be high or, again, may be but slightly elevated. The pulse is rapid and later becomes thready and uncountable. Therefore, in any patient who fails to do well following operation, the possibility of a general peritonitis should be considered and when suspected the usual regimen (Ochsner) for the treatment of peritonitis should be instituted. This consists in Fowler's position, hot applications to the abdomen, nothing by mouth, liberal quantities of morphine, duodenal syphonage, intravenous fluids, glucose and sodium chloride, blood transfusions, oxygen and drugs of the sulfonamide group. Secondary operations are rarely indicated, as the outcome depends chiefly upon the resistance of the patient and the virulence of the infection. As in any other case of peritonitis treated by the Ochsner regimen, careful vigilance is necessary in order to detect local abscesses as they develop. When present, these should, of course, be drained at an early date.

#### SECONDARY OR RESIDUAL ABSCESES

Secondary intra-abdominal abscesses are prone to occur in certain fossae or regions of the peritoneal cavity. These abscesses may represent a favorable termination in cases of general peritonitis which have been treated conservatively and in which the patient has succeeded in overcoming his infection. In our experience, about 60 per cent of the patients with general

peritonitis treated by the deferred operative method, develop abscesses. Similarly, abscesses may be encountered in cases of general peritonitis which have been treated by prompt operation and they may develop regardless of whether or not drainage was instituted and whether or not the appendix was removed. Moreover, they may occur as a postoperative complication following drainage in cases of a localized appendiceal abscess and here, again, regardless of whether or not the appendix was removed. It is for this reason that contamination of the uninvolved peritoneum should be avoided, and that extraperitoneal drainage should be performed whenever possible. Rarely such abscesses may develop as a complication of appendectomy when only a local peritonitis was present at the time of operation. C. W. Cutler, Jr.,<sup>12</sup> in a study of 1,651 patients with acute appendicitis operated upon at the Roosevelt Hospital, found secondary abscesses which required further surgery in thirty-three patients. Such abscesses were found in 4.5 per cent of all cases of suppurative appendicitis. In this group of thirty-three cases, about 60 per cent followed general peritonitis, whereas the remainder occurred as a complication of suppurative appendicitis with local or spreading peritonitis. In his series the mortality was 21 per cent in the entire group, or 13 per cent if the subphrenic abscesses were excluded.

As shown in Figure 1, the common sites for these secondary or residual abscesses are (1) the pelvis, in which case the abscess occupies the cul-de-sac of Douglas, (2) the left lower quadrant, (3) the subdiaphragmatic spaces, and (4) the ileocecal region. True residual abscesses following general peritonitis are often found either in the pelvis or in the subphrenic spaces. This is due to the fact that with the patient in the recumbent position, the marked anterior convexity of the lumbar spine tends to deflect purulent exudates upward or downward, allowing collections to form in the more dependent or isolated recesses of the peritoneal cavity. For the same

reason, residual abscesses in the mid-abdomen are uncommon.

The presence of a secondary intra-abdominal abscess is often suggested by the fact that following operation fever persists, or subsequent to a fall to normal, it suddenly becomes elevated several days later. Along with this, the patient experiences a certain amount of abdominal pain or discomfort, the location of which may be of some diagnostic value. If the process continues for a considerable time, the temperature curve exhibits septic swings and the patient appears worn and haggard from the effects of the continued sepsis. He feels weak and exhausted, has anorexia and malaise and later may develop a secondary anemia. Physical examination reveals localized tenderness on abdominal, rectal, or vaginal examination and a mass may be palpable. Infections in the subphrenic spaces are more difficult to detect and require special attention and study.

*Pelvic Abscesses.* Abscesses situated in the rectovesical or recto-uterine pouches are the most common of the residual abscesses. In fact, this is the most desirable location for such abscesses and one of the advantages of the Ochsner regimen in the treatment of peritonitis, either independently or in conjunction with operation, is the assistance which it renders in localization of the general infection in the pelvis. With the patient in the recumbent position, the cul-de-sac becomes the most dependent portion of the peritoneal cavity. Whether the factor of gravity alone is important in allowing exudates to settle in the pelvis is problematical. Nevertheless, Fowler's position is one of maximum comfort for the patient and when abdominal distention is marked, it relieves pressure on the diaphragm and thus diminishes respiratory embarrassment. The old view that absorption is less rapid from the pelvis than from the diaphragmatic peritoneum, is no longer tenable. In the pelvis, however, there is a minimal amount of movement, whereas in the subphrenic spaces, localization is interfered with through the constant mo-

tion of the diaphragm. All agree that localization of infection in the pelvis is much to be preferred to localization in the

morphine are among the most important items in this regard. Gastroduodenal suction and the intravenous administration

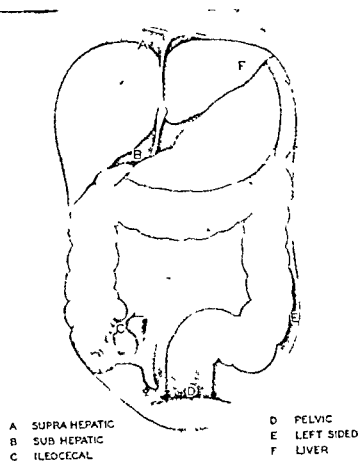


FIG. 1. Diagrammatic sketch showing the more common locations of the residual or secondary intraperitoneal abscesses associated with appendicitis. (Redrawn from Ochsner, A., Gage, I. M. and Garside, E. The intra-abdominal postoperative complications of appendicitis. *Ann. Surg.*, 91: 544, 1930.)

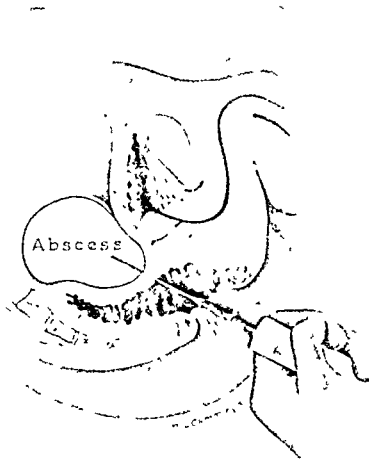


FIG. 2. Diagram showing method of confirming diagnosis of abscess in the rectovesical pouch. If pus is obtained on aspiration, drainage by rectum is then instituted.

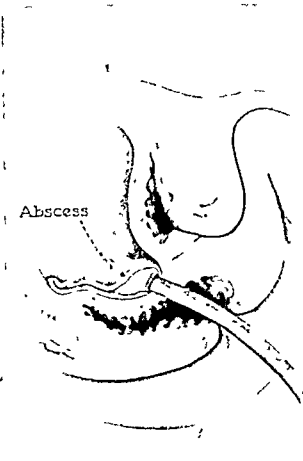


FIG. 3. A short longitudinal incision has been made through the anterior wall of the rectum at the site of the needle puncture and a stiff rubber tube inserted. The tube is held in place by means of one suture through the rectal wall. The end of the tube is left long and extends out through the anus.

subphrenic or subhepatic spaces, since in the pelvis recognition of an inflammatory mass or abscess is far easier and, also, since here surgical drainage, should it become necessary, is a simpler procedure. It is common experience that the mortality of pelvic abscesses is lower than that of abscesses situated in the upper quadrants of the abdomen. As in the case of localization of infection at any other point in the peritoneal cavity, the presence of an inflammatory mass or area of infiltration does not necessarily denote a true abscess. It is only when suppuration has taken place that surgical drainage is indicated. The majority of these inflammatory masses will undergo spontaneous resolution under proper conservative treatment and such treatment should first be given a thorough trial. The principles involved are essentially those entailed in the treatment of general peritonitis. Restriction of all food and fluid by mouth and the liberal use of

solutions of glucose and sodium chloride are valuable adjuncts. Under conservative therapy, over one-half of such pelvic masses will subside and no operative intervention will be necessary.

**Diagnosis.** A pelvic abscess should always be suspected in any patient who, following operation, continues to run a septic course. Wound infection and other causes of fever, e.g., urinary tract infection, pneumonia, thrombophlebitis, etc., should, of course, be considered and excluded. Abscess formation in the cul-de-sac is always to be looked for in patients being treated conservatively for general peritonitis. Daily rectal examinations should be made. An inflammatory mass or infiltration is easily felt as a hard, firm, tender tumor mass bulging into the upper rectum anteriorly. It is usually felt at the tip of the examining finger. Subjective symptoms referable to the bladder, e.g., dysuria, urgency or frequency may be present. In the later

stages, diarrhea is not uncommon. Repeated digital examination of the rectum will enable the surgeon to follow changes in the size of the mass. Thus it may diminish, an indication of spontaneous resolution, or it may enlarge downward. Areas of softening indicative of suppuration should be sought for. Large cul-de-sac masses may arise out of the pelvis and then become palpable on abdominal examination. As suppuration occurs in a pelvic mass, the anal sphincter relaxes and the anus becomes patulous. The rectal mucosa becomes edematous and succulent and has a soft, thick, velvety feel. When these findings are encountered, surgical drainage is indicated. In general, our preference is for abdominal drainage and this should be performed in the extraperitoneal manner. Many surgeons, however, more or less routinely advise drainage by way of the rectum or vagina. In rectal puncture there is always the danger of injury to the great vessels of the pelvis. The bladder may also be injured during this procedure and Stafford and Sprong report a fatality due to this accident which was followed by a persistent rectovesical fistula and a fatal ascending infection of the urinary tract. In our opinion, rectal drainage should be reserved for those pelvic abscesses which are large and which point low down in the rectum, and in which a large area of softening can be demonstrated. When this is the case, the diagnosis is first confirmed by aspiration of the abscess with a large gauge needle. (Fig. 2.) The bladder having been emptied previously, the patient is placed in the lithotomy position. If pus is obtained on aspiration, drainage of the cavity is established by making a vertical incision in the anterior rectal wall at the site of the needle puncture, evacuating the pus and inserting drains. (Fig. 3.) In properly selected cases, this is a very simple technical procedure and provides an efficient form of drainage. Undrained cul-de-sac abscesses may spontaneously rupture into the rectum and thereby undergo spontaneous cure.

*Left Lower Quadrant Abscesses.* Ab-

scesses in the left lower quadrant of the peritoneal cavity occasionally occur but are relatively uncommon. They are encountered more frequently as a postoperative complication than in patients undergoing conservative treatment for general peritonitis. Barrow and Ochsner call attention to the fact that abscesses in this locality are seen only in patients with a shallow pelvis and that they are most often found in children. They frequently are associated with an abscess which fills the pelvis and then extends upward and points to the left. The general signs and symptoms are those of any other secondary or residual abscess plus the localizing signs of tenderness, possible muscle spasm and skin edema, and a palpable mass in the left lower quadrant. The principles of treatment are similar. Here, again, it should be mentioned that many will subside spontaneously. If suppuration occurs, drainage will be necessary and is best performed through a small muscle splitting incision, taking care to avoid contamination of the main peritoneal cavity. As a rule, there is no great urgency for surgical intervention and, before proceeding with surgery, one should be certain that suppuration has taken place and ample time should be allowed to be certain that firm adhesions are present, in order that these protective barriers are not broken down in the process of drainage.

*Subdiaphragmatic Abscess.* Suppurative disease of the appendix is responsible for more instances of subphrenic abscess than any other single lesion. Ochsner and DeBakey<sup>13</sup> in their analysis of 3,533 cases of subphrenic abscess, collected from the world literature, found lesions of the appendix to be the etiological factor in 30.9 per cent, and in 25.3 per cent of their own seventy-five cases. In 15,000 collected cases of acute appendicitis, they calculate that subphrenic abscesses occurred as a complication in 0.9 per cent. They emphasize the point that many subphrenic infections do not progress to the stage of abscess and, also, the fact that due to



difficulties in diagnosis many subphrenic abscesses are never recognized. Faxon,<sup>14</sup> in a recent communication, reported 124 consecutive operative cases of subphrenic abscess at the Massachusetts General Hospital, and found the etiology to be a lesion of the appendix in thirty-eight, or 31 per cent. Wellman and Maddock,<sup>15</sup> in a review of fifty-two cases of subphrenic abscess, observed at the University of Michigan Hospital over a ten-year period, found that twenty-one, or 40.3 per cent, occurred as a complication of appendicitis.

The mechanism whereby infection may reach the subdiaphragmatic spaces from the somewhat distant right iliac fossa is of interest. The route most often described is that of direct extension along the right paracolic gutter. Overholt,<sup>16</sup> by experimental studies, has demonstrated the fact that a negative pressure is created in the upper abdomen by respiratory movements, and this would tend to cause septic material to be aspirated upward and into this region. Considerable attention has been given to the possibility of extension by way of the lymphatics by Munro,<sup>17</sup> Barnard,<sup>18</sup> and Truesdale.<sup>19</sup>

In order to appreciate fully the significance of subphrenic infections, a brief review of the anatomy of the region is necessary. Following the earlier descriptions by Martinet<sup>20</sup> and Barnard,<sup>21</sup> the term subphrenic region has come to denote that space in the upper abdomen bounded superiorly by the diaphragm and inferiorly by the transverse colon and mesocolon. Thus, subhepatic abscesses properly belong in this group. Detailed descriptions of the anatomy of the region are found in the excellent treatises by Ochsner,<sup>22,23,24</sup> Nather and Ochsner,<sup>25</sup> Ochsner and DeBakey, Ochsner and Graves,<sup>26</sup> and by Faxon.<sup>27</sup> The main subphrenic space is divided by the liver into a suprahepatic and an infrahepatic portion. Each of these compartments is in turn subdivided into three smaller spaces. Passing from the diaphragm to the liver, the falciform suspensory ligament divides the supra-

hepatic space into right and left spaces of approximately equal size. The right suprahepatic space is divided by the lateral extension of the cardinal ligament of the liver, i.e., the right lateral ligament into a large right anterior superior space and a smaller posterior superior space, leaving a single left superior space. The infrahepatic space is also divided into right and left halves by the round ligament and the ligament of the ductus venosus. While there is but one right inferior space, on the left side and separated by the stomach and gastrohepatic omentum are the left anterior inferior and the left posterior inferior spaces.

The right posterior superior space is the one most commonly involved in all subphrenic abscesses, and this is especially true in those infections of appendiceal origin. Thus Ochsner and DeBakey found in a review of 1,461 cases of subphrenic abscess that the right posterior superior space was involved in 33.7 per cent, and in 55.7 per cent of their own seventy cases. In Faxon's study, the right posterior superior or right inferior spaces were involved in 66 per cent of the cases in which the infection originated in the appendix. Subphrenic abscesses may be residual, as in cases of a resolving general peritonitis, or secondary when infection has extended from the appendix to the peritoneum but when general peritonitis has not occurred. With regard to diagnosis, the condition is suggested by continued evidence of sepsis (fever and leucocytosis) in a patient known to have had a local or general appendiceal peritonitis and in whom evidence of a suppurative process elsewhere in the abdomen, as well as extra-abdominal causes for fever have been excluded. Faxon stresses the following points in the history and examination: (1) tenderness over the twelfth rib or lower costal margin, sometimes best elicited by compression of the thorax, (2) findings indicative of a high, fixed diaphragm on the affected side, and (3) manifestations of diaphragmatic irritation, e.g., pain referred

to the shoulder or neck, hiccoughs and discomfort on deep respiration. The liver is often displaced downward.

duced into the abdominal cavity and since it may remain unabsorbed for as long as two weeks, its presence may confuse the

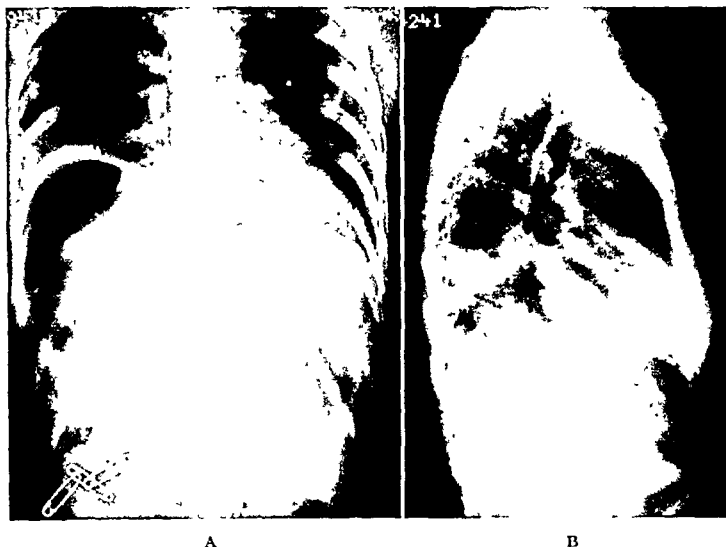


FIG. 4. A, roentgenogram in anteroposterior projection showing the appearance in a late case of subdiaphragmatic abscess. The right diaphragm is elevated and a large gas bubble is seen beneath the diaphragm. B, lateral projection in same case as A. The large collection of gas under the diaphragm is shown.

The roentgenological examination will assist materially in the diagnosis, although the roentgen findings are not pathognomonic until the late stages when a gas bubble and fluid level can be demonstrated. (Fig. 2.) However, in conjunction with consistent clinical findings, roentgen evidence of a high fixed diaphragm and an associated pleural effusion calls for a presumptive diagnosis of subphrenic abscess. (Figs. 3 and 4.) In order to be of the greatest assistance, particularly in the localization of the infection, the roentgenological study should include, in addition to the usual anteroposterior films, lateral views as well as fluoroscopic examination. (Fig. 5.) In the case of patients who continue to have unexplained fever following perforation of the appendix, it is our practice to have roentgen studies of the diaphragm every third day since, in such instances, the possibility of infection in the subphrenic spaces must always be borne in mind. It is to be remembered that at the time of laparotomy or abdominal paracentesis, air may be intro-

duced into the abdominal cavity and since it may remain unabsorbed for as long as two weeks, its presence may confuse the picture. At the present time most authors condemn the practice of aspiration of the subphrenic spaces as a diagnostic procedure. It is an unreliable method, as failure



FIG. 4. c, anteroposterior projection, with patient lying on left side. The large collection of air is shown and a definite fluid level is present. The irregular shadows in this film at the left are due to the injection of lipiodol into a sinus tract resulting from a previous unsuccessful attempt at drainage.

to obtain pus does not exclude abscess. Moreover, the danger of contamination of uninvolved portions of the peritoneum, the pleura, or both, cannot be minimized. When, however, the question is one of differential diagnosis between subphrenic

abscess and empyema, a carefully performed thoracentesis is not objectionable. Ochsner and DeBakey suggest that ap-

They are most likely to occur when, due to errors in judgment, drainage was omitted at the time of the original operation. In



FIG. 5. Early roentgen findings in a case of subdiaphragmatic abscess. The right diaphragm is elevated and there is partial obliteration of the costophrenic sulcus due to pleural effusion. Fluoroscopy showed the diaphragm on this side to be immobile.



FIG. 6. Roentgenogram in case of right subphrenic abscess with an unusually extensive associated pleural effusion. In this case, repeated thoracenteses were performed before the correct diagnosis was made. It was after these were done that the fluid level appeared, due to the air introduced at the time of the taps. Cultures of the fluid were consistently negative.



FIG. 7. Roentgenogram in case of subdiaphragmatic abscess involving the right anterosuperior space. This shows the value of the lateral projection in the localization of the abscess.

proximately 75 per cent of the cases of subphrenic infection will subside spontaneously under conservative measures, and suppuration demanding surgical drainage will occur in only 25 per cent. They believe that when the aforementioned findings suggesting subphrenic space infection fail to subside within a week, it is justifiable to assume the presence of an abscess and to proceed with surgery. In cases in which the diagnosis remains in doubt, exploratory operation is advised by them since, if performed extraserously, the risk is slight. The technical procedures for extraserous drainage are well described in the papers by Ochsner devoted to this matter. Undrained subphrenic abscesses may rupture through the diaphragm, with a resultant empyema, bronchopleural fistula, pneumonia or lung abscess.

*Right-sided or Ileocecal Abscess.* These local abscesses are relatively uncommon as postoperative complications, especially in cases where drainage has been employed.

the early stages before a definite mass has developed, they may be confused with a wound infection. The symptoms and signs may be similar. In each there is continued fever, tachycardia, leucocytosis, pain, tenderness, swelling and induration in the neighborhood of the wound. Later, in the case of an ileocecal abscess, an intra-abdominal mass becomes recognizable. In either case, whether localized intraperitoneal infection or wound sepsis, the early treatment is conservative, i.e., hot wet dressings, physiological rest and chemotherapy. If an intra-abdominal abscess is suspected, the usual conservative measures for peritonitis should be employed in order to facilitate localization and to minimize the danger of spread of infection beyond the right iliac fossa. Under these conditions the mass becomes more localized and later may increase in size if suppuration occurs. Suppuration is disclosed by the presence of softening or possibly fluctuation, while the temperature chart reveals a "picket

fence" type of curve. When this takes place, surgical drainage is indicated. However, the operation should not be performed until one is certain that the surrounding adhesions are sufficiently strong so as not to be broken down easily, since contamination of the remainder of the peritoneal cavity must be avoided and every effort should be made to perform an extraperitoneal type of drainage operation. In cases of general peritonitis, treated conservatively by the Ochsner regimen, the right iliac fossa is a common site for localization of the infection and subsequent abscess formation. The diagnosis and treatment of these abscesses are essentially the same as in the case of those which occur postoperatively. It is important to note that the majority of abscesses encountered in the right lower quadrant occur not as a postoperative complication, but rather primarily following the slow perforation of an infected appendix. Far more common than the true abscesses, are the inflammatory masses or infiltrations in this region, and a distinction between these two lesions should be made. In the treatment of such inflammatory masses, whether true abscesses or inflammatory infiltrations, Lehman and Parker<sup>28</sup> advocate conservative therapy. During the years 1936 to 1937, 83.3 per cent of their abscess cases were treated along conservative lines and 65 per cent were carried through without operation. Under certain conditions they found it necessary to abandon conservative therapy and resort to surgical intervention. Such operative procedures are classed as "forced operations." They regard as indications for a forced operation during the course of conservative treatment, acute intestinal obstruction, or growth in the size of the abscess, with threatened perforation into the anterior abdominal wall or rectum along with an associated increase in the signs of sepsis. It has been pointed out by Wangenstein<sup>29</sup> that prolonged delay in draining large abscesses is attended with certain dangers, since such an abscess may rupture into the free peritoneal cavity, an

accident which is almost invariably fatal, as the unprepared peritoneum is then suddenly flooded with septic material and an overwhelming infection of the peritoneum ensues. Again, such an undrained abscess may burrow into the mesentery and cause erosion of a large blood vessel, with disastrous results.

#### DISORDERS OF THE LIVER

*Pylephlebitis and Liver Abscess.* Fortunately, hepatic abscesses occur but rarely as a complication of the septic appendix, but constitute a most serious problem when present. The mode of spread of infection whereby suppurative appendicitis is responsible for hepatic abscesses is most often by way of the portal vein, i.e., following pylephlebitis. A less common cause is extension to the liver from a subphrenic space infection or abscess. Ochsner, De-Bakey and Murray,<sup>30</sup> in a series of 575 cases of pyogenic abscess collected from the literature, found 197, or 34.2 per cent, to be secondary to appendiceal disease. In their own series of forty-seven cases of pyogenic liver abscess, five, or 10.6 per cent, were due to appendicitis, while in their personal series of 5,293 cases of acute appendicitis over a ten-year period, there were five instances of secondary liver abscess, an incidence of 0.094 per cent. The liver abscesses complicating acute appendicitis are usually multiple, and the right lobe is more commonly involved than the left. Occasionally, small abscesses may coalesce to form a large solitary abscess.

The usual clinical picture of pylephlebitis and liver abscesses complicating acute perforated appendicitis is characterized by high fever and chills, usually of abrupt onset. There is localized pain and tenderness in the region of the liver. The liver is enlarged. In the study of Ochsner, De-Bakey and Murray, jaundice proved to be a less common finding than is generally supposed. These authors found jaundice to be present in only 36.4 per cent of their collected cases, and 24.7 per cent in their own series. When present, it was a late

development and they regard its presence as of grave prognostic import. Koster<sup>31</sup> emphasizes the importance of splenomegaly ascites and tenderness along the course of the portal vein as of diagnostic significance. The leucocyte count is often unusually high, with a proportional increase in the percentage of polymorphonuclear leucocytes. Roentgen studies are of value and show elevation and fixation of the diaphragm, particularly the right. In the series of Ochsner, DeBakey and Murray, a positive roentgen diagnosis was made in twenty-three of twenty-eight cases examined roentgenologically, or an incidence of 82.1 per cent. Koster suggests the use of thorium dioxide (thorotrast) in cases in which there is doubt of the diagnosis, and also for the purpose of determining the character and extent of the suppurative process in the liver. He administers the drug intravenously in doses of 25 cc. on three successive days, following which roentgenograms are taken. In normal persons the x-ray shadow of the liver is of uniform density. An abscess will appear as an area of lesser density, and in multiple abscesses the liver shadow will show a mottled appearance. Judging from the reported cases, this procedure seems to be of value as far as accuracy of diagnosis is concerned. However, sufficient evidence has not yet accumulated to determine whether or not thorotrast is entirely without danger. Most authors condemn exploratory puncture of the liver in doubtful cases. While the prognosis of pyogenic abscess of the liver is decidedly bad, this is particularly true in the case of multiple lesions, the type most often found in association with appendicitis. Thus in the series reported by Ochsner and his associates, the mortality for single abscesses was 37.5 per cent in contrast with a mortality of 95 per cent in the cases in which multiple abscesses were present.

*Acute Hepatitis.* Simeone and Stewart<sup>32</sup> report two cases of acute appendicitis with perforation and general peritonitis in which, during the postoperative period,

bleeding due to hypotherbinemia occurred. This, they believe, was due to disturbed liver functions consequent upon an acute hepatitis which, in turn, was due to severe intraperitoneal sepsis. Since, under such circumstances, such bleeding may result in marked loss of blood and extension of infection, they recommend frequent plasma prothrombin determinations in cases of peritonitis. Since the hypotherbinemia is due to a depression of liver function, the administration of vitamin K is less effective than usual and, therefore, in addition to its use, repeated blood transfusions should be given.

#### ILEUS

Ileus, as a postoperative complication, may be of two types, (1) acute mechanical intestinal obstruction and (2) adynamic or paralytic ileus. A distinction should be made between these two types, although in some instances the two may co-exist.

VanBeuren<sup>33</sup> reports that of 130 patients with acute ileus operated on at the New York Presbyterian Hospital from 1932 to 1935, eight, or 6 per cent, occurred as complications of acute appendicitis. The incidence of late obstructions due to adhesions following operations for acute appendicitis would be considerably higher. VanBeuren also found that in 380 patients with acute appendicitis coupled with acute diffuse peritonitis operated on at the Presbyterian Hospital between 1916 and 1938, acute ileus developed as a postoperative complication in twenty-eight cases, or 7.4 per cent. This author reports a mortality of 56 per cent in a series of thirty-four cases of acute ileus complicating acute appendicitis with abscess or general peritonitis. In this group of cases, the mortality of the mechanical type of ileus was 47 per cent, whereas that of the paralytic type was 63 per cent.

*Acute Mechanical Obstruction.* Due to adhesive bands, a loop of bowel, usually the terminal ileum, may be caught and angulated so that a mechanical obstruction is produced in cases of localized or general

peritonitis. While these recent light adhesions are unlike the dense, firm adhesive bands seen in late adhesive obstructions, nevertheless they are entirely capable of causing complete mechanical blockage to the flow of the intestinal stream. This is made possible because of the fact that in peritonitis, and especially in patients having had an operation involving an unusual amount of trauma or manipulation, there is associated some degree of paralytic ileus. Due to the consequent loss of the normal propulsive power of the intestinal muscle, the coils become dilated with fluid and gas and a dangerous angulation at the point of fixation occurs. Great distention of the bowel interferes with its blood supply and, if not corrected, may lead to necrosis of the wall with perforation. Many of the postoperative obstructions, therefore, represent a combination of mechanical and adynamic ileus.

While the diagnosis of small intestinal obstruction due to adhesive bands but occurring weeks, months or years after operation is ordinarily easily made, the recognition of this type of obstruction which occurs during the postoperative period may be more difficult. Here, as in postoperative general peritonitis, the symptoms may be relatively mild and insidious. They often are overshadowed by persistence of the symptoms and signs of the original peritonitis. Thus abdominal pain and obstipation are difficult of evaluation. However, during the postoperative period, any increase in pain, especially if it is colicky and cramp-like in character, should be the cause for concern. Nausea and vomiting, if persistent and severe, should suggest mechanical or paralytic ileus. The presence of "fecal" vomiting is indicative of a low obstruction. Abdominal distention is due either to mechanical or adynamic ileus. In mechanical obstruction, auscultation reveals active peristalsis. This examination likewise is of less value than in those patients who are not convalescing from an abdominal operation and peritonitis. X-ray examination is of the greatest impor-

tance. The simple flat plate or scout film of the abdomen, taken with the patient in the supine position, is usually sufficient. The administration of barium by mouth is absolutely contraindicated and a very ill patient should not be subjected to complicated or prolonged examinations. Wangenstein<sup>34</sup> has pointed out that while gas is normally present throughout the gastrointestinal tract, it is visualized in the x-ray film of the abdomen only in the stomach and colon, except in the case of patients under three years of age. In the small intestine, while gas is present, it is so intimately mixed with fluid that it is not visualized under conditions of normal peristaltic activity. When stasis occurs due to mechanical or functional ileus, the fluid and gas separate and gas can be demonstrated. If ileus is present, dilated small bowel may be seen within a few hours following the onset, and subsequent films may demonstrate a progression of the process. Dilated small bowel is recognized by its central position, its feathery cross striations and the transverse position of the parallel coils. (Fig. 8.) The presence of many coils suggests a low obstruction, and any great degree of asymmetry suggests a mass as the cause of the displacement. (Fig. 9.) By means of the roentgenogram alone, it is impossible to distinguish between mechanical and adynamic ileus. Blood chemistry studies show an increase in the nonprotein nitrogen, a fall in the plasma chlorides and usually an increase in the carbon dioxide combining power. In these early postoperative adhesive obstructions, treatment by gastroduodenal suction after the method of Wangenstein<sup>35</sup> or, preferably, by the use of the "long" Miller-Abbott tube, is eminently successful. In this type of case, in the past, simple enterostomy usually effected a prompt cure. The decompression of the distended coils of bowel above the obstruction served to release the kink at the site of fixation and, with the resumption of peristaltic activity, this complication was corrected. At the present time, intestinal suction

achieves the same result by means of what might be termed as "internal enterostomy" and surgical intervention is rarely neces-

dilates and remains motionless. It becomes filled with its normal secretions and, since these are not moved onward, upper gastro-



FIG. 8. "Scout film" of abdomen in case of small intestinal obstruction. This shows the parallel arrangement and transverse position of the intestinal coils and their central location in the roentgenogram. The fine cross-striations are characteristic of dilated small intestine.



FIG. 9. "Scout film" of abdomen showing high grade obstruction of the small bowel with gaseous distention of the ileum and jejunum. There is an absence of bowel pattern in the right lower quadrant, suggesting the presence of a mass at that point.

sary. Occasionally, in low obstructions in which adequate decompression is impossible by means of duodenal suction and in which technical difficulties are encountered in the passage of the Miller-Abbott tube beyond the pylorus or the ligament of Treitz, enterostomy may be necessary in order to avoid further delay and, in the very ill patient, to avoid the exhausting effects of repeated fluoroscopic manipulations. Still less frequently, gastroenteric suction may fail to relieve the obstruction and reoperation becomes necessary in the event that it is due to some unrelated condition.

*Adynamic Ileus.* Adynamic, paralytic or functional ileus is an accompaniment of peritonitis and may be regarded as a protective mechanism insofar as, with its occurrence, peristaltic activity ceases. Here, there is no single point of occlusion of the lumen of the bowel. Due to the loss of its contractile power, the intestine

intestinal stasis ensues. Due to reverse peristalsis, vomiting follows. Pain ordinarily is not severe or characteristic. The abdomen is distended and is silent on auscultation. Due to pressure on the diaphragm, respiration may be embarrassed. As already mentioned, mechanical and functional ileus may frequently co-exist.

The treatment of adynamic ileus is the treatment of the underlying peritonitis. The patient should be kept in the Fowler's position. Here, the use of duodenal suction by the method of Wangensteen is of the greatest value. Gastroduodenal suction serves to keep the upper portion of the digestive tract free of gas, swallowed air and retained secretions. Drugs such as eserine or pituitary derivatives are contraindicated because of the danger of spreading infection if violent peristalsis is stimulated. Moreover, they are inefficient in restoring the normal tonus and rhythmical contractions of the bowel.

Morphine, on the other hand, has a stimulating effect upon the intestinal musculature by increasing tone and rhythmic contractions, as shown by Orr.<sup>36</sup> Since it also minimizes the discomfort of the indwelling duodenal tube and the intravenous needles, it should be used freely. Plasma chlorides should be maintained at a normal level. Ochsner<sup>37, 38, 39</sup> recommends heat applied to the abdomen by means of body bakes. He believes that, due to the vasodilatation produced in the abdominal wall, there is a reciprocal vasoconstriction in the splanchnic areas which, in turn, has a beneficial effect upon distention. Distention may also be combated by oxygen therapy employing high concentrations of oxygen as recommended by Fine.<sup>40</sup> As the body defenses begin to overcome the infection, the tone and activity of the bowel will return to normal.

#### FECAL OR INTESTINAL FISTULA

Fecal fistula is an uncommon complication of operation for acute appendicitis, either with or without an associated peritonitis. In a series of ninety-four cases of intestinal fistula seen at the University of Michigan Hospital between the years of 1925 and 1934, and studied by Ransom and Collier,<sup>41</sup> thirty, or 32 per cent, developed following operations upon the appendix. Eight of these developed in the hospital following operation. In all of them the infection had extended beyond the appendix at the time of the original operation, and there was either a local abscess or a general peritonitis. These eight fecal fistulas occurred among 234 cases of acute appendicitis with abscess or general peritonitis, and which were treated by operation, an incidence of 3.4 per cent. The incidence of fistulas for the total number of operations for acute appendicitis with and without perforation (1,067) was only 0.8 per cent. In a series of 109 fecal fistulas observed in the Johns Hopkins Hospital over a period of forty years, Lewis and Penick<sup>42</sup> found that forty-nine, or 44.9 per cent followed appendicitis. Marshall and Lahey<sup>43</sup> found

perforated appendicitis to be the etiological factor in ten of the thirty-seven cases of abdominal fistulas reported by them. These authors state that the most common cause of intestinal fistula is an infection which produces gangrene and perforation of the bowel and that, in their experience, cecal fistulas usually were the result of a direct extension of an infection of the appendix to the cecal wall, with a resultant sloughing of the wall. Fistulas involving the small intestine were more often the result of secondary operations for pelvic abscess or intestinal obstruction and were due to injury to the small bowel at the time of operation. Dixon and Deuterman<sup>44</sup> mention that a fecal fistula may follow drainage of an appendiceal abscess in cases in which the appendix is not removed at the original operation, since a fecolith in the remaining portion of the appendix may cause the development of such a fistula. Probably in some cases an unrecognized and unrelieved intestinal obstruction in the terminal ileum results in perforation of the bowel at the point of the obstruction, whereupon a fistula ensues.

Because it is believed by some surgeons that postoperative fistulas are due to improper treatment of the appendiceal stump, there has been much discussion in the literature regarding the merits and disadvantages of invagination of the stump at the time of appendectomy. Some authors maintain that such a technic is responsible for a high incidence of fecal fistulas, whereas it is contended that simple ligation without invagination reduces this incidence. It has been our practice to invert the stump with a purse-string suture of catgut or silk, or by means of three mattress sutures of silk whenever the condition of the cecal wall will permit this procedure. We have seen no instance of fecal fistulas which we could attribute to invagination of the appendiceal stump, and similar experiences are recorded by Lewis and Penick and by Dixon and Deuterman. Some fistulas are caused by the use of improper drainage materials. Fortunately,



glass and hard rubber drains, once so commonly used, have been largely superseded by drains of soft rubber, gutta-percha, or drains of the cigarette variety. A heavy gauze drain allowed to remain in contact with a suture line is apt to provoke leakage; hence, when cigarette drains are used, the gauze should not project beyond the end of the Penrose tubing. The tip of the drain may be placed near but not against the suture line. Moreover, when feasible, it is well to interpose the omentum between the suture line and the drain.

In the forty-nine cases of fistulas following appendicitis reported by Lewis and Penick, the opening was in the cecum in twenty-one, or 72.4 per cent, in the ileum in four, or 13.7 per cent, and in the appendix in a similar number of cases. In the remainder of their cases, the point of communication could not be determined. In the thirty fistulas associated with appendicitis studied by Ransom and Collier, the opening was in the terminal ileum in thirteen, in the cecum in four, in both cecum and ileum in two, in the sigmoid in one, and was undetermined in ten cases.

The diagnosis of an intestinal fistula ordinarily is not difficult. In the case of most cecal fistulas, the discharge is semi-solid and is not especially irritating to the skin. The fistulas higher in the small intestine are associated with an irritating discharge and, due to the fluid character of the contents, considerable quantities of fluid, electrolytes and food substances may be lost. Occasionally, it may be difficult to distinguish between a fecal fistula and a colon bacillus infection of the wound or in a hematoma. Dixon mentions the importance of the history of the passage of gas in such cases as indicative of fistula and, in doubtful cases, suggests the use of a dye such as carmine red by mouth. Roentgen studies following injection of the fistulous opening with some radio-opaque material is often of value in localization. Injection in conjunction with a barium enema often gives additional information.

The fistulas associated with appendicitis

tend to heal spontaneously. This is particularly true of the cecal fistulas. When healing fails to occur in these cases there is usually an outgrowth of the cecal mucous membrane so that it becomes continuous with the skin, producing the direct or lip type of fistula. In such cases, surgical closure is necessary. The ileal fistulas are more apt to be complete and are less likely to heal spontaneously than are those in the cecum. Here, the added complications of spur formation, herniation, or obstruction distal to the fistula are mechanical factors which serve to maintain the fistulous opening and they must be recognized and corrected by the proper surgical procedures. As a rule, in the fistulas associated with appendicitis, conservative treatment should be given a prolonged trial before resorting to operative closure. Even though a surgical repair may be necessary at a later date, a successful result is much more likely to be obtained when the local inflammatory reaction has been given a chance to subside before operation is attempted.

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# JAUNDICE

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WHEN a case of jaundice is encountered, certain questions are at once evident: Is the jaundice attributable to hemolytic, obstructive or hepatogenous processes? Is a combination of causes present? Will surgical intervention be necessary for relief, and if so, what is the opportune time for operation and can the risk of such a procedure be reduced by preoperative medical measures? Are any special procedures advisable during the postoperative course? In many instances, these questions can be answered readily, but in others, to find the answers requires considerable search. As in the treatment of other diseases, experience adds measurably to the facility with which the internist arrives at his conclusions. No matter how extensive a physician's clinical experience may be, however, cases will be encountered in which a definite preoperative diagnosis cannot be made and in which the answer may have to await exploratory operation or examination at necropsy.

In elucidation of the problems of jaundice, it is necessary to have a working classification of the various causative factors. (Table 1.) Obstructive jaundice most commonly is due to stones in the biliary tract, cicatricial strictures of the common duct, malignant processes involving the head of the pancreas or ampulla of Vater, or metastatic lesions about the common bile duct or in the liver. Hepatogenous jaundice may be caused by a large variety of lesions, the most common of which are the various forms of hepatitis of endogenous, exogenous or idiopathic origin, cirrhosis and infections, such as catarrhal jaundice, Weil's disease and suppurative cholangitis. The rare case of constitutional hyperbilirubinemia also is

probably of hepatic origin, such as demonstrated in Case 1. The hemolytic group includes pernicious anemia and congenital or acquired hemolytic icterus.

TABLE 1  
CLASSIFICATION OF JAUNDICE

- i. Obstructive jaundice
  - A. Choledocholithiasis
  - B. Cicatricial stricture of the common bile duct
  - C. Malignant obstruction
    1. Carcinoma of the head of the pancreas
    2. Carcinoma of the papilla of Vater
    3. Carcinoma of the gallbladder and bile ducts
    4. Metastatic malignant lesions involving the liver, bile ducts or periportal lymph-nodes
  - D. Acute or subacute pancreatitis
- ii. Hepatogenous jaundice
  - A. Circulatory disease
    1. Chronic passive congestion
    2. Thrombosis of portal or hepatic vein
  - B. Suppurative infections
    1. Cholangitis
    2. Portal pyelephlebitis
    3. Hepatic abscess
  - C. Nonsuppurative infections
    1. Epidemic catarrhal jaundice
    2. Weil's disease
    3. Yellow fever
    4. Malaria
    5. Syphilis
    6. Typhoid
    7. Pneumonia
    8. Influenza, etc.
  - D. Toxic degenerations
    1. Exogenous—arsenic, cinchophen, alcohol, chloroform, etc.
    2. Endogenous—hyperthyroidism, toxemias of pregnancy, etc.
    3. Idiopathic—yellow atrophy
  - E. Cirrhosis
  - F. Constitutional hyperbilirubinemia
- iii. Hemolytic jaundice
  - A. Hemolytic icterus—congenital or acquired
  - B. Pernicious anemia
  - C. Transfusions of incompatible blood
  - D. Toxins—phenylhydrazine, etc.
  - E. Infections—malaria, bacterial endocarditis as examples
  - F. Miscellaneous hemolytic processes

An accurate and detailed history of attacks and symptoms is also necessary in elucidation of the problem. In a large

majority of cases a complete and accurate history will permit a satisfactory classification of the type of jaundice present. Confirmatory evidence and more detailed information can be obtained from physical examination and the various laboratory procedures, including some of the many tests for hepatic function.

#### HISTORY

Stone in the common bile duct is the most frequent cause of jaundice that is amenable to surgical operation. The diagnosis in such cases is best established by the history. Since this is true I first shall describe the symptoms which stone in the common duct may produce. I then shall change the point of view and consider certain symptoms often mentioned by patients who have jaundice and suggest the underlying disease.

*Stone in the Common Duct.* The classical story of chronic indigestion of gaseous type, with qualitative and quantitative relation to food, together with the occurrence of biliary colic, is well known. Many variations, however, are common. Chronic indigestion may be absent. Colic may be absent or atypical in character or location. The patient may complain of short spells of indigestion, commonly represented by a sensation of fullness, pressure or aching in the upper portion of the abdomen. At times, relief is obtained by induced belching, vomiting, or bowel movements. These attacks may occur at any time of the day or night. Nocturnal awakening suggests organic disease. The attacks may last from a few minutes to an hour or more and tend to occur with increasing frequency and to persist longer. There may not be any residual soreness. Eventually, a physician's care is required. As time progresses, other symptoms or signs may be manifest, such as slight fever, mild chills, residual soreness in the right upper quadrant of the abdomen and even mild jaundice of transitory nature. The alert physician recognizes the significance of these signs and symptoms at once. Some patients,

however, delay seeking medical advice until their symptoms are more severe and associated with marked decline in their general health. Patients for whom diagnosis of stone in the common duct often is difficult from the history alone are those of advanced years who always have enjoyed good health. Their tolerance for pain is high; they tend to minimize the significance of indigestion and find it difficult to give an adequate account of their symptoms. Their age and previous good health always arouse suspicion of possible malignant disease when any digestive symptoms develop.

*Colic Followed by Jaundice.* In general, however, the history of attacks of colicky pain in the upper portion of the abdomen followed by jaundice means the presence of stone in the common duct. Such definite attacks frequently are associated with chills and fever. Jaundice after such attacks varies in duration and degree; commonly, it is relatively mild (the value for serum bilirubin averages 10 mg. per 100 cc.) and tends to clear in from one to two weeks. In other instances, it is deeper and persists indefinitely, although it may fluctuate considerably. Exacerbations of pain often precede increase in jaundice. With the onset of jaundice, concomitant discoloration of the urine and lightening of the color of the feces occur, although many patients do not observe these changes until their attention has been called to them. Such changes aid little in determining the cause of the type of jaundice present.

Although colic followed by jaundice usually means stone in the common bile duct, a similar history occasionally is encountered in cirrhosis of the liver, at the onset of jaundice as a result of carcinoma of the head of the pancreas and of acute pancreatitis. Cases II and III are illustrative of such conditions.

*Jaundice without Pain.* Onset of jaundice not associated with pain is attributable to a wider variety of causes and offers a greater problem in diagnosis, especially if bile can be demonstrated entering the

intestine. The physician should be particularly careful to inquire concerning the ingestion of hepatotoxic drugs, the presence of epidemic jaundice, the history of preceding infection of the respiratory or gastrointestinal tract and any history of preceding, mild attacks of jaundice. Jaundice of painless onset among young patients is most frequently hepatogenous; among older patients, it most frequently is attributable to malignant lesions obstructing the biliary tract, especially if the jaundice is intense, persistent and associated with marked pruritus. Absence of bile in the intestine and a palpable, distended gallbladder usually establish the diagnosis in this type of jaundice. In such cases, there may be a preceding history of a few months' duration characterized by indefinite discomfort in the upper portion of the abdomen, impairment of appetite, loss of weight, and, at times, mild diarrhea. The diarrhea consists of occasional stools which are bulky, loose and light-colored because of excess fat. Occasionally, jaundice occurring without pain is attributable to stone in the common bile duct. If expectant management is employed, the occurrence of pain followed by increase or decrease of icterus may clarify the situation. In some instances, physical examination and results of various laboratory procedures may elucidate the nature of difficult problems. Again, it may be necessary to undertake exploration before a satisfactory explanation is found.

*Pruritus.* Pruritus is a common accompaniment of obstructive jaundice. It is, however, often absent or minimal in degree in cases of jaundice attributable to stone in the common bile duct, especially if jaundice is mild. It more frequently is present and commonly is more intense in the deep jaundice that accompanies malignant obstructions of the bile ducts. Pruritus is absent in hemolytic jaundice unless some complicating factor, such as cholelithiasis or hepatic cirrhosis, is present. A variable number of patients who have hepatogenous jaundice suffer from pruri-

tus. Commonly, cases are encountered in which severe degenerative lesions of the liver are associated with intense jaundice, such as acute yellow atrophy, without pruritus. Pruritus is infrequently a symptom of atrophic cirrhosis. Nevertheless, pruritus of severe degree, persisting over long periods and associated with mild, slowly deepening jaundice and melanosis, usually is indicative of a certain type of primary hepatic disease. Confirmatory evidence usually can be obtained by physical examination, tests for hepatic function and subsequent course of the patient.

*Diarrhea and Steatorrhea.* Diarrhea is an uncommon symptom in jaundiced conditions, although in cases in which it occurs it appears to be due to insufficient bile in the intestine to permit adequate absorption of ingested fats. In cases of obstruction of the pancreatic duct, steatorrhea may be present for some weeks or months before the malignant lesion producing obstruction involves the bile duct and causes jaundice.

*Edema, Ascites and Hematemesis.* A history of edema and ascites not attributable to cardiac or renal disease usually means extensive primary or malignant disease of the liver, with obstruction of the portal system and other changes. However, in a few long-standing and neglected cases of stone in the common bile duct with secondary biliary cirrhosis, such symptoms may be present. Hematemesis usually has a similar significance, although in an occasional case it may be due to an associated lesion, such as gastroduodenal ulceration or malignant disease.

#### DIAGNOSIS IN CASES IN WHICH OPERATION HAS BEEN PERFORMED PREVIOUSLY

For the patient who has had previous surgical operation on the gallbladder or bile ducts and whose presenting symptom is jaundice, accurate diagnosis is much more difficult. A knowledge of the symptoms that led to the operation, the operative findings and procedures is almost

imperative; this information should be obtained from the patient or surgeon. Many combinations of symptoms may be encountered in such cases. The simplest would be a preoperative history of gallstones and jaundice and acute inflammation of the gallbladder found at operation, with establishment of drainage the only surgical procedure performed. In these cases, the surgical treatment obviously is incomplete. When circumstances permit, a second operation with opening of the common bile duct is indicated. Stone in the common bile duct usually is found, although in some instances edema of the biliary tract and pancreas attributable to the infection may cause jaundice. However, exploration of the common bile duct usually is necessary. In other instances of cholecystic disease, the gallbladder has been removed; it may or may not have contained stones and convalescence may have been normal. Sooner or later, colic associated with fever and, at times, chills and jaundice develop. This situation most frequently is attributable to stone in the common bile duct. If colic develops within a short time after operation and if some jaundice has been present before operation, an overlooked stone is the most likely cause of the trouble. If some years have passed before the onset of symptoms, a stone of postoperative origin is probably the cause of the trouble. Postoperative colic may occur for months or years before jaundice develops; in such cases, exploratory operation is indicated.

Stricture of a cicatricial nature is the next most common cause of postoperative jaundice. Various combinations of symptoms have been described in this condition. In the usual case, the course is stormy after cholecystectomy, characterized by development of jaundice within two or three days postoperatively, with pain, fever and spontaneous development of an external biliary fistula. The fistula tends to persist. With development of the fistula, the jaundice may clear and pain and fever subside. As time progresses, however, the

fistula tends to close and the pain and jaundice recur. Re-establishment of the fistula relieves the symptoms. In complete stricture, persistent jaundice and fistula are not unusual. In incomplete stricture, the fistula may close permanently. Jaundice may or may not have disappeared entirely but soon recurs or deepens in association with attacks of colic-like pains, chills and fever. These attacks increase in frequency, the jaundice tends to become permanent and all bile may disappear from the stool. The liver and spleen frequently become enlarged. In other cases, convalescence after cholecystectomy is much milder. Attacks of biliary obstruction, characterized by pain, chills, fever and jaundice develop after the wound has healed, increase in frequency and eventually reach a stage of permanent jaundice. I encountered a case in which these symptoms began two years after uncomplicated cholecystectomy was performed.

Cholangitis is a third factor in the cause of jaundice and colic after cholecystectomy. Its pathogenesis and mechanism are not well understood. Usually, stone or partial stricture is suspected until the common bile duct is explored. Even then, a small stone may be overlooked. Prolonged drainage of the common bile duct may not give the expected relief.

Biliary fistula persisting after cholecystostomy usually is attributable to residues of cholecystic disease, stone or obstructive lesions of inflammatory or neoplastic nature of the common bile duct. Further surgical procedures usually are required. From time to time, as the fistula closes, pain and jaundice may develop. If pancreatic enlargement was found at operation and cholecystostomy was performed merely to relieve the jaundice and pruritus, or as a phase of a procedure in two stages, in which subsequent anastomosis between the gallbladder and stomach or duodenum is planned, the external flow of bile usually is profuse and none enters the intestine. Dehydration and other nutritional changes are common in such instances. Persistent

fistula after cholecystectomy usually is due to an overlooked stone in the common bile duct or stricture. Jaundice may or may not be present. If drainage of the common bile duct has been established and external flow of bile continues after removal of the tube, some obstructive lesion in the lower portion of the common bile duct usually is present, such as overlooked stone, stricture, pancreatitis or neoplasm of the ampulla of Vater or pancreas.

#### PHYSICAL EXAMINATION

On examination of jaundiced patients, yellow discoloration of the skin is first noted. An impression of the degree or intensity of jaundice thus is obtained, although in cases of deep icterus the degree of bilirubinemia seldom can be gauged accurately. The tint of pigmentation also is noted. A lemon-yellow tint of relatively mild degree suggests the presence of a hemolytic process. An intense orange is indicative, although not always, of hepatogenous jaundice, and a green tint suggests obstructive jaundice of considerable duration. Pigmentation, aside from that attributable to retention of bile often is encountered in cases of obstructive or hepatogenous jaundice of long standing. This usually is brownish and is attributable to melanosis. Scratches may be numerous if pruritus is present.

On abdominal examination, the size, consistency and contour of the liver are determined and the presence of tenderness or rigidity is noted. Palpable enlargement of the gallbladder is searched for, and its size, contour, movability, consistency and tenderness are noted. Enlargement of the gallbladder usually is attributable to empyema, obstruction of the cystic duct and obstructions at the ampulla of Vater. Discernment of an enlarged gallbladder often is difficult, especially if the abdominal walls are tense and thick. Among obese patients, it seldom can be palpated. At times it is difficult to differentiate a distended gallbladder from an irregular margin of the liver.

Other points worthy of note include the presence of abdominal scars, fistulas or sinuses, splenic enlargement, distended veins, other abdominal masses and ascites. In the general examination, special note is made of enlarged lymph-nodes, possible metastatic nodules, including those in the rectum; pallor, cyanosis, purpura or other evidence of bleeding; clubbing of the fingers; spider angiomas; distended veins; edema; bile tophi; loss in weight and temperature.

*Patency of the Bile Ducts.* The next step in a study of the jaundiced patient is a determination of patency of the bile ducts; in other words, to determine whether bile is entering the intestine and in what quantity. Chemical examination of the feces for bile and use of duodenal intubation usually establish this satisfactorily. It should be noted that at times chemical tests for bile may be negative, although variable amounts of bile can be demonstrated entering the intestine by duodenal intubation. In choledocholithiasis, bile usually can be demonstrated entering the intestine, although occasionally a stone may be impacted firmly in the region of the ampulla of Vater, thus completely obstructing the passage of bile. In carcinoma of the ampulla or pancreas, "dry drainages" usually are encountered, especially in the later stages. In earlier stages the jaundice may even clear to a great extent for a short time; frequently, in such cases, blood may be obtained on duodenal aspiration. In performance of duodenal drainage, adequate control of the method is essential in order to be certain that the duodenum has been entered.

#### LABORATORY EXAMINATION

*Roentgenoscopic Examination.* Roentgenoscopic examination does not aid greatly in the diagnosis in cases of jaundice. Cholecystography is of no value because of hepatic disease or obstruction of the biliary tract. Occasionally, roentgenograms of the region of the gallbladder will demonstrate stones, but rarely is a shadow seen that

suggests stone in the common bile duct in cases in which cholecystectomy has been performed. Roentgenoscopic examination of the gastrointestinal tract is valuable in excluding primary malignant lesions that may have metastasized to the liver. Occasionally, widening of the duodenal loop may indicate enlargement of the head of the pancreas. Cholelithograms are valuable in studying biliary fistulas and, especially, patency of the common bile duct if drainage tubes are in place.

*Tests for Hepatic Function.* The number of tests for hepatic function are almost legion. Too frequently, more information is anticipated from these tests than their originators indicated. Again, many tests are used and the results are overemphasized or misinterpreted; often, too, the data obtained from the history and physical examination are ignored. It generally is recognized that there is no one test that gives an entire picture of the condition of the liver and that no test will distinguish between hepatogenous and obstructive jaundice. Furthermore, employment of any test depends on its simplicity and accuracy. At the Mayo Clinic, a great many of the various tests for hepatic function have been employed, but, after experimental clinical trials, their use has been discontinued. Some of the tests that are still utilized will be considered herein:

*The van den Bergh Reaction.* Qualitatively, the van den Bergh reaction is always direct in cases of well developed obstructive and hepatogenous icterus. The reaction, however, does not aid in distinguishing between these types. Theoretically, the reaction is indirect in cases of hemolytic jaundice, but in cases of more marked icterus in which the value for serum bilirubin is from 6 to 10 mg. per 100 cc., a direct reaction commonly is encountered. In certain of the cases of hemolytic jaundice, however, direct reaction indicates the presence of a superimposed obstructive element, such as stone in the common bile duct or early hepatic damage.

Quantitatively, the reaction is valuable in determining the degree of jaundice and in following fluctuations in its intensity from time to time. The degree of bilirubinemia gives some information in regard to the condition of the liver. For example, in calculous obstruction of the common bile duct, the level of serum bilirubin is commonly from 8 to 12 mg. per 100 cc. If obstruction is complete, this level may be increased to 18 to 20 mg. However, levels higher than this indicate definite hepatic damage, apparently in direct proportion to the degree of retention. In carcinomatous obstruction, which may be more or less complete, levels of from 15 to 20 mg. are usual. Levels of 25 mg. or more have a significance similar to high levels present in cases of choledocholithiasis; levels as high as 50 mg. have been encountered. In hepatogenous jaundice, high levels have a similar significance; levels as high as from 15 to 20 mg. are not unusual and values of from 30 to 40 mg. indicate severe hepatic damage.

The van den Bergh reaction also is valuable in excluding evidence of hepatic disease in such conditions as carotenemia, pigmentation attributable to atabrine and in demonstrating biliary or hepatic disease in borderline cases, such as early hepatitis, cirrhosis or toxic conditions in which gross icterus is not present. The test also is valuable after attacks of abdominal pain that lack distinguishing characteristics, demonstrating in such instances the presence of a latent jaundice.

*The Icterus Index.* This is a simple method of following the course of jaundiced patients, but it lacks some of the advantages of the van den Bergh reaction, such as distinguishing hemolytic jaundice, familial hyperbilirubinemia, latent obstructive or hepatogenous jaundice and carotenemia.

*The Bromsulfalein Test.* This test is seldom of value in cases of jaundice, except in determination of hepatic function in hemolytic or latent jaundice. Its chief importance is in a study of hepatic function in the absence of jaundice.



*Determination of Blood Cholesterol and Cholesterol Esters.* Increased values for blood cholesterol and cholesterol esters in obstructive jaundice and reduction of these values in association with degenerative hepatic lesions commonly are encountered. A marked lowering of the levels often has prognostic significance. In many cases in both types, however, fairly normal values may be obtained. Occasionally, marked elevation of cholesterol and cholesterol esters occurs in chronic degenerative conditions, as demonstrated in Case iv.

*Synthesis of Hippuric Acid and Galactose Tolerance Tests.* These tests give some information concerning the function of the liver, but they do not aid greatly in distinguishing between obstructive and hepatogenous icterus. In many cases of each type, values may be normal. Again, synthesis of hippuric acid in obstructive jaundice may be decreased and excretion of galactose may be abnormally high, indicating a rather severe, associated hepatic disturbance in addition to the obstructive element. Conversely, abnormal results of these tests do not mean that an obstructive element is not present as a factor in producing jaundice.

*Prothrombin Clotting Time.* The prothrombin clotting time should always be estimated in cases of jaundice, both before and after administration of vitamin K and it should be estimated frequently in the course of convalescence of patients who have been treated surgically. A normal clotting time does not exclude the necessity of administering vitamin K, at least preoperatively and, for a period, postoperatively. Delay in the prothrombin clotting time demands delay in surgical procedures and indicates the urgent need of vitamin K. Failure to obtain reduction of the prothrombin clotting time from adequate administration of vitamin K usually indicates severe hepatic disease, even if the jaundice is primarily of obstructive origin.

*Other Studies on Blood.* Other studies of the blood occasionally give some definite information of the seriousness of dis-

turbed physiologic processes in jaundice and in postoperative study of cases in which progress is not satisfactory. Included in these are estimations of urea, sugar, carbon dioxide combining power, chloride, protein, calcium and amino acids. In cases of severe jaundice, the kidneys frequently are involved and elevation of urea occurs. In certain cases of primary hepatic disease, lowered values for urea and sugar are encountered. If an external biliary fistula or drainage tube is present after operation, disturbances of the content of chloride and carbon dioxide combining power are at times encountered, indicating dehydration or acidosis. These changes occur most frequently if choleresis is manifest. The choleresis is a further indication of disturbance of hepatic function of considerable degree. These changes indicate that replacement or other treatment is necessary; and at times, they may show that it is necessary to apply a clamp or remove the drainage tube.

In some cases, especially cases of choleresis, a marked lowering of the cholesterol and bile salts in the excreted bile is present and indicates a serious prognosis. Occasionally, a patient who has chronic hepatic disease, including certain cases of hepatic disease of obstructive origin, either with or without external fistulas, may manifest marked osteoporosis with spontaneous fractures. The level of calcium in the blood usually is lowered. Lowered levels of serum proteins, especially albumin, are encountered commonly in primary hepatic disease and in cases in which the postoperative course is long and serious and the intake of food has been inadequate and hemorrhage or infection has occurred.

#### COMMENT

Disturbances of hepatic function as determined by one or more of the tests mentioned have definite clinical significance, although this varies with the degree of abnormalities. In all instances, however, the results of the tests should be subservient to sound clinical appraisal in

each case. Intensive preoperative treatment is indicated in those cases in which disturbances of hepatic function are present and surgical procedures are planned. Exploration should be deferred until all possible improvement has occurred and, when undertaken, adequate follow-up treatment is indicated. If satisfactory progress has not been made preoperatively, the operation may of necessity have to be proceeded with, in spite of the increased risk of such an undertaking. In the nonsurgical case, the results of these tests often serve as a guide in the treatment and progress of the patient. The following report of cases encountered at the Mayo Clinic illustrates some of the problems of diagnosis, the methods of using laboratory procedures and their significance.

#### CASE REPORTS

**CASE I.** A woman, aged twenty-four years, had noted slight scleral icterus, slight indigestion and nausea after ingestion of fatty foods for six months prior to registration. The family history in regard to the blood, liver and spleen was negative. Pruritus was absent. The icteric index ranged from 12 to 25. The liver and spleen were palpable, but this may have been because of extensive scoliosis, causing displacement of the organs. On laboratory investigation, the value for serum bilirubin was 4.2 mg. per 100 cc.; the van den Bergh reaction was indirect. The cholecystogram disclosed a normally functioning gallbladder. The number of leukocytes and erythrocytes, differential count and morphologic elements of the blood were normal; fragility of erythrocytes was normal and sedimentation rate (Westergren method) was 6 mm. per hour. Retention of bromsulfalein was normal. The value of cholesterol was 196 mg. and that of cholesterol esters 120 mg., each per 100 cc. of plasma.

*Comment.* The only positive finding in this case was the hyperbilirubinemia. Investigation of the blood, liver and gallbladder failed to demonstrate any disease process. The hyperbilirubinemia in this case was considered attributable to constitutional hepatic dysfunction. Investiga-

tion in such cases is largely by means of laboratory procedures.

**CASE II.** A man, aged forty-one years, had an attack of moderately severe colic in the right upper portion of the abdomen and vomiting one month prior to registration. Thirty-six hours after this attack jaundice, which deepened and persisted, pruritus, acholic stools and loss of twenty pounds (9.1 kg.) occurred. For two years he had suffered from mild indigestion. Examination revealed deep jaundice and slight enlargement of the liver. The value of serum bilirubin was 15.4 mg. per 100 cc.; the van den Bergh reaction was direct. At operation, a large, tense gallbladder, dilated common bile duct and tumor of the head of the pancreas were found. Cholecystogastrostomy was performed. The subsequent course confirmed the diagnosis of carcinoma of the pancreas.

*Comment.* The preceding indigestion and colic, followed by jaundice and absence of palpable gallbladder, were suggestive of gallstones. None were found. In carcinoma of the pancreas, the onset of jaundice may be associated with colic, thus simulating stone in the common duct. In some cases of carcinoma of the pancreas, stones occasionally are encountered in the gallbladder or common bile duct and may or may not have given rise to atypical symptoms.

**CASE III.** A man, aged forty-six years, who had used alcohol moderately, had suffered from gaseous indigestion and attacks of pain in the right upper quadrant of the abdomen of varying severity and increasing frequency for fifteen years. These attacks had frequently been associated with chills and fever. For twenty years he had noted increasing dyspnea on exertion and for two weeks, dependent edema.

On admission the patient was suffering from severe pain. The temperature was 104°F. Moderate jaundice, tenderness in the right upper quadrant of the abdomen and edema of the lower extremities were present. Laboratory investigation revealed 27,400 leukocytes per cubic millimeter of blood, marked macrocytosis and a value for serum bilirubin of 6.2 mg. per 100 cc.; the van den Bergh reaction was direct. The value of cholesterol was 214 mg., and that of cholesterol esters 103 mg., each per 100 cc. of plasma. The value of total protein was

5.5 gm. per 100 cc. of serum. The albumin-globulin ratio was 1:1.6; excretion of hippuric acid was 0.37 Gm. Operation revealed a small, markedly hobnailed liver and some ascites. Gallstones were absent. Necropsy revealed cirrhosis of the liver.

*Comment.* The clinical picture indicated choledocholithiasis so strongly that exploration seemed indicated in spite of evidence of seriously impaired hepatic function, as indicated by edema, low value for total protein, decreased synthesis of hippuric acid and macrocytosis. Dyspnea, in the absence of cardiac, renal and pulmonary disease, and edema were clinical symptoms indicating chronic hepatic disease. Primary hepatic disease may thus mimic the syndrome of cholecystic disease and choledocholithiasis. The similarity is usually so striking that exploration cannot safely be avoided.

**CASE IV.** The patient, a man aged forty-three years, presented a history of biliary colic of three years' duration. The last attack had occurred ten days prior to registration and was followed by deep, persisting jaundice. He had lost thirty pounds (13.6 kg.) in four months.

Examination revealed deep icterus and slight tenderness in the right upper quadrant of the abdomen. The value for serum bilirubin was 19.7 mg. per 100 cc.; the van den Bergh reaction was direct. Small amounts of bile were entering the duodenum; result of the galactose tolerance test was normal and the value for blood cholesterol was 340 mg. per 100 cc. At operation, the gallbladder was distended, thick-walled and contained white bile and pus, but no stones. A stone, 1.2 cm. in diameter, was removed from the lower end of the dilated common bile duct and a T-tube inserted for drainage. Marked hepatitis was present. Postoperatively, from 750 to 1,000 cc. of bile drained daily. A slight rise in the level of serum bilirubin occurred, followed by a slow decline. On the fifth day drowsiness was noted. These abnormalities were corrected by means of solutions of glucose administered intravenously.

*Comment.* The history in this case seemed to indicate choledocholithiasis. The presence of deep jaundice with incomplete obstruction of the common bile duct indi-

cated hepatic damage in addition to the obstructive element. This was confirmed by appearance of the liver at operation and the presence of moderate cholestasis, drowsiness, rise in the level of serum bilirubin and its slow decline postoperatively. The high level of serum bilirubin was the only evidence of hepatic damage as indicated by the laboratory procedures used preoperatively.

**CASE V.** A woman, aged thirty-six years, complained of pruritus and spells of indigestion, anorexia and mild pain in the upper portion of the abdomen for two years. For a year the stools had been lighter and the urine darker than normal. Scleral icterus had been noted for three months. The patient had lost twenty pounds (9.1 kg.). Colic, chills or fever had not been experienced.

Examination revealed mild icterus, melanosis, marked excoriations of the skin and slight enlargement of the liver and spleen. Xanthelasma, edema, ascites or varicosities of the abdomen and esophagus were not demonstrated. The value for hemoglobin was 11.6 Gm. per 100 cc. of blood; erythrocytes numbered 4,160,000 per cubic millimeter of blood; macrocytosis was present and the value of serum bilirubin was 9.8 mg. per 100 cc.; the van den Bergh reaction was direct. Cholecystograms revealed gallstones. Excretion of hippuric acid was 3.7 Gm. Values were as follows: cholesterol 1,010 mg., cholesterol esters 694 mg., each per 100 cc. of plasma.

The diagnosis was primary hepatic disease associated with stones in the gallbladder. At operation, the liver was increased in size and firmer in consistency than normal. The gallbladder was opened, stones were removed and drainage was established. The common bile duct was normal in size, but was opened, probed and a T-tube inserted for drainage. During convalescence, 150 to 250 cc. of bile drained daily through the T-tube; one specimen contained 1,000 mg. of bile salts per 100 cc. The pruritus was relieved temporarily but recurred later. The jaundice remained stationary. The level of fats in the blood dropped moderately.

*Comment.* Some of the symptoms probably were attributable to gallstones. Absence of colic, chills, fever or fluctuations

in the jaundice and the long-standing, pre-icteric pruritus, together with enlargement of the liver and spleen, indicated primary hepatic disease. Macrocytosis and the elevated levels of blood fats tended to confirm this. The degree of bilirubinemia and the direct van den Bergh reaction gave no assistance in distinguishing the type of jaundice present. Nevertheless, the presence of the gallstones necessitated exploration and jaundice demanded investigation of the common bile duct. The surgical findings confirmed the preoperative diagnosis.

Increased levels of cholesterol and cholesterol esters in the blood are encountered commonly in obstructive jaundice, but seldom to the degree seen in this case. On the other hand, they are often reduced, at times markedly, in acute hepatic disease. The increase noted in this, an instance of chronic hepatic disease without obstruction of the common bile duct, is occasionally encountered in cases of similar type or in obstructive biliary cirrhosis. The significance of this disturbance is unknown, but apparently has only a slight effect on the surgical risk.

**CASE VI.** The patient, a man, aged sixty-five years, complained of not feeling well for six months prior to registration. For five weeks his appetite had been impaired. Occasionally, he had noted slight discomfort and nausea after eating. Jaundice of painless onset had been noted for two weeks. He had lost thirty pounds (13.6 kg.). Pruritus was not a complaint.

Examination revealed deep jaundice and slight enlargement of the liver. A mass was not palpable in the abdomen. Anemia was not present. Duodenal drainage revealed moderate flow of bile. The value for serum bilirubin measured 18.2 mg. per 100 cc.; the van den Bergh reaction was direct. Excretion of hippuric acid was reduced to 1.4 Gm. Results of the galactose tolerance test were normal. The value of blood cholesterol was 214 mg. and that of cholesterol esters 88 mg., each per 100 cc. of plasma. Prothrombin clotting time of the blood was twenty-four seconds.

After preoperative preparation exploration was performed. The liver was found to be somewhat irregular in shape but was otherwise

normal. The gallbladder was collapsed and its wall somewhat thickened; it was opened and drained. The common bile duct was small, but probes passed into the duodenum without meeting any obstruction. In the region of the common hepatic duct, there was possibly some narrowing, which was suspected as being neoplastic. A T-tube was inserted in the common bile duct.

Convalescence was normal. One hundred to 700 cc. of bile drained daily from the common bile duct. The jaundice gradually decreased, but the value of serum bilirubin remained at 4 mg. per 100 cc. during the last two weeks of observation.

*Comment.* The patient's age and previous good health, the painless onset of deep persisting jaundice and the loss in weight suggested the presence of neoplasm. The presence of bile entering the intestine indicated that obstruction, if any, was incomplete. The degree of jaundice in the absence of complete obstruction, the reduced synthesis of hippuric acid and lowered level of cholesterol esters in the blood pointed to rather severe and acute hepatic involvement. The findings at operation were not conclusive. It was thought that a malignant lesion of the hepatic duct may have been present. However, the drainage tube was inserted in the common bile duct below this level and the external flow of bile was free. The jaundice cleared to a large degree. The common bile duct was not enlarged nor was there obstruction at its lower end. The whole picture can best be explained on the basis of an acute hepatic degenerative process, from which complete recovery may occur or in which improvement may be followed by relapses, progressing to acute atrophy or cirrhosis. Exploration probably served no useful purpose in this case except as an aid in the diagnosis. In a fair number of cases, however, exploration cannot be avoided. Although administration of anesthetic agents and surgical manipulation may aggravate a primary hepatic condition, nevertheless, cases are frequently encountered in which improvement seems to result.

CASE VII. A woman, aged sixty-eight years, had had severe, persistent pruritus and mild, painless jaundice for three years. In the ten previous years, there had been occasional attacks of moderate, colicky pain in the right upper quadrant of the abdomen. Slight indigestion had been noted. The gallbladder had been removed elsewhere ten months prior to registration. The patient understood that it had contained muddy material. Drainage had not been established. Convalescence was satisfactory but the symptoms had continued. Weight and strength had been maintained reasonably well.

Physical examination revealed many excoriations, mild jaundice and some enlargement of the liver; the liver itself was smooth. Duodenal drainage revealed an excellent flow of amber-colored bile. Anemia was absent, but generalized macrocytosis was present. The value of serum bilirubin was 5.2 mg. per 100 cc.; the van den Bergh reaction was direct. Prothrombin clotting time of the blood was normal. Excretion of hippuric acid was reduced to 1.4 Gm. The value of cholesterol was 555 mg. and that of cholesterol esters 417 mg., each per 100 cc. of plasma.

On exploration, the liver was enlarged, reddish and somewhat mottled. Moderate hepatitis was present. The common bile duct was normal in size and did not disclose evidence of obstruction. A T-tube was inserted for drainage. One hundred to 185 cc. of bile, which contained large amounts of bile salts, drained daily until the tube was removed on the twenty-first postoperative day. The fistula closed promptly. The jaundice was slightly lessened at the time of dismissal from the clinic. The pruritus was relieved temporarily.

*Comment.* The onset of this illness associated with severe and persistent pruritus and followed immediately by mild

nonfluctuating jaundice indicated a primary hepatic disorder. Further indications were the maintenance of weight and strength, the enlarged liver, apparent absence of biliary obstruction at the time of original operation, as indicated by normal convalescence without development of fistula, and absence of pain or fluctuations in her condition postoperatively. However, the uncertainty of the operative findings and continuation of the jaundice led to further exploratory operation. Tests for hepatic function were inconclusive in distinguishing possible obstruction of the common duct with associated secondary biliary cirrhosis from primary hepatic disease. At operation no pathologic process amenable to surgical relief was encountered. The diagnosis was primary hepatic disease and the prognosis is unfavorable. It probably represented an early stage of cirrhosis in which jaundice and pruritus were prominent symptoms.

#### SUMMARY

An adequate history and physical examination, determination of the patency of the bile ducts and the use of tests for hepatic function usually will establish the diagnosis as to the type of jaundice present, the nature of the underlying pathologic process, such as stone, stricture, malignant disease, hepatic degeneration or hemolytic process, the possibility of a combination of factors and some knowledge of the functional capacity of the liver. Indications for surgical treatment usually will be manifest, together with some information as to the possibilities of postoperative difficulties.



# SPECIFIC INFLAMMATORY DISEASES OF THE LOWER BOWEL

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## GENERAL CONSIDERATIONS

TO attempt diagnosis of diseases of the lower bowel by symptomatology is a great mistake. It is not unusual for a patient with cancer of the lower bowel to describe symptoms easily interpreted as being of inflammatory origin; likewise, it is often difficult or impossible to differentiate between organic and functional diseases by symptomatology alone. To attempt diagnosis from symptoms will inevitably lead to error, embarrassment and sometimes tragic results.

These errors can be avoided by examining the patient. The facilities required need not be elaborate or expensive. Simple digital examination, which should be routine in all general examinations, will often disclose valuable information. All patients who have symptoms referable to the lower bowel should have a routine endoscopic examination. For this, the inverted position is preferable because of the advantage gained by partial straightening of the sigmoid due to gravitation and by the tendency of the bowel to balloon which makes observation easier. The lower bowel should be emptied, preferably by repeated plain warm enemas taken two or three hours prior to the examination. A suction apparatus with a long tip is an added advantage in removing excessive mucus or fluid, although in many instances this can be accomplished by using cotton swabs.

Valuable information may often be obtained by accessory examinations. X-ray visualization is indispensable in many cases and should be done by one qualified in gastrointestinal fluoroscopy. A flat film of the barium filled colon is sometimes of value but it is essential that this be pre-

ceded by fluoroscopic observation as the contrast medium is being introduced into the colon. Thus, filling defects and other abnormalities which sometimes do not show on the film may be detected. It is well to remember that x-ray diagnosis in the distal colon (below the pelvic brim) is unreliable, but fortunately this segment of the bowel is easily visualized on endoscopy.

Biopsy specimens for microscopic study may easily be removed during endoscopy. Diagnostic culture and smear specimens are best obtained directly from the lesions during endoscopic examination; if stool specimens are used for this purpose the large amount of extraneous material may unnecessarily complicate and confuse the picture.

The sequence of diagnostic procedures is important. The clinical examination, including endoscopy and removal of biopsy and bacteriologic specimens, should precede the introduction of contrast media into the bowel for x-ray study. Endoscopy is likely to increase bowel irritability and spasm. For this reason it is advisable, if possible, to delay x-ray examination for twenty-four hours, or longer, following endoscopy.

The anatomic accessibility for examination of the rectum and colon affords opportunity for diagnostic accuracy that exists in few other organs. With reasonable basic knowledge of the physiology and pathology of the intestinal tract, the percentage of accurate diagnoses should be high.

Disorders of the lower bowel can be divided into two general classes: functional and organic. Functional disorders will be disregarded here and organic diseases of inflammatory origin only will be discussed.

Tropical diseases, typhoid fever and certain rare and controversial infections will not be considered.

One or more of the following symptoms should arouse suspicion of organic colonic disease:

1. Increased constipation or looseness of stools.
2. The passage of pathologic fluids, such as blood, pus or excessive mucus.
3. Frank diarrhea, acute or chronic, with or without blood, colic, pain, fever or weight loss.
4. "False alarms," that is, defecatory desire with passage of little but gas, pus, and mucus, with or without blood.
5. Necessity of getting up at night because of persistent desire to defecate.
6. Persistent abdominal pain or tenderness.
7. Loss of weight not otherwise accounted for.

It should always be remembered that colonic or rectal cancer may produce any of these symptoms.

The treatment of these diseases is primarily *medical* although *surgery* is occasionally required, especially when complications arise.

*Treatment in general* should include careful dietary management and efforts to secure physiological rest. During acute and subacute stages of any colonic infection the patient should remain in bed. Liquid and semisolid foods, without irritating residue, are usually well tolerated during acute stages. Among these are rice, oatmeal and barley gruels, lamb, chicken and beef broths, egg albumen, fermented milk and gelatine. Milk is considered undesirable in most cases. As acute manifestations subside, nonirritating solid foods, such as lean, chopped beef, boiled or poached eggs, toast, custards, chicken and lamb chops may be allowed. Adequate vitamin intake, especially the B group, should not be overlooked. As recovery progresses the diet can be increased. Irritating foods, such as cauliflower, celery, corn, cabbage, fried foods, gravies, raw fruits, lobster, crab,

alcohol, and condiments, should not be eaten until recovery is complete.

*Symptomatic medication* should be used freely. The colon is influenced by psychic factors and every effort should be made to keep the patient physically comfortable and mentally at ease. During acute attacks with distressing symptoms, adequate doses of morphine, or other opiates should be used. Later the barbiturates and other sedatives are useful to promote repose. Demulcents and antispasmodics often serve a useful purpose. Hot stupes are sometimes effective in relieving abdominal distress.

#### CHRONIC ULCERATIVE COLITIS

This is an inflammatory disease of the colon presenting characteristic pathologic changes, most frequently occurring between the ages of twenty to forty. Its chronic course is often interrupted by acute exacerbations and its effect may be devastating.

The *etiology* is a controversial matter. The excellent work of Barger and his associates has thrown a great deal of light on the subject. Their belief, based upon convincing laboratory and clinical research, is that it is a specific bacterial disease produced by a diplostreptococcus which they have isolated. Other workers, whose opinions must be respected, have been unable to duplicate Barger's findings and have advanced other hypotheses of etiology. Thorlakson believes *Bacillus dysenteriae* to be the cause, while Paulson is inclined to think it is idiopathic; McCarri-son, Mackie, and others, believe avitaminosis to be an important factor, and other observers have incriminated various organisms. The bacterial flora of the normal colon is neither simple nor constant and pathologic changes may produce a bewildering complex.

The *pathologic changes* in chronic ulcerative colitis are typical. In probably more than 90 per cent of all cases the lesions first occur in the rectum or lower sigmoid within easy reach of the sigmoidoscope. In the early stages, diffuse inflammation and

edema of the mucosa occur which are followed by the formation of innumerable minute abscesses; these later break and form the tiny ulcers which are so characteristic. As the disease progresses these ulcers may coalesce and, due to secondary infection, form large, ragged, denuded areas. In severe cases, only remnants of mucosa may be recognized.

The inflammatory process extends deep into the bowel wall. It may remain localized to a single segment, or the entire colon may become involved. The mucosa sometimes becomes studded with polypoid growths, perirectal abscesses are not infrequent, and less frequently perforation and fatal peritonitis occur. Visualization by x-ray shows the involved bowel to be thickened, narrowed, and shortened, with obliteration of the normal haustral markings.

The early *symptoms* may be mild and later become severe and prostrating, depending on the progress of the disease. Passages of blood, pus and mucus are characteristic, and the number of passages in twenty-four hours may vary from one or two to twenty or thirty or even more. In severe cases most of the movements may consist entirely of bloody mucopus without admixture of feces. Tenesmus, with or without colic, is usually present and may be distressing. As the disease progresses, constitutional symptoms, such as malaise, anorexia, general weakness, low grade fever and loss of weight become evident.

The *diagnosis* is suggested by the symptoms. The proctoscopic picture in most cases is typical as described above in pathologic changes. The ulcerated area is bathed in mucopus and bleeds on slightest trauma. The normally sharp margins of the valves of Houston become thickened and rounded, and lose their normal elasticity. Cultures should be taken with a sterile applicator directly from the ulcerated area and transferred to Rosenow's medium. If the technic described by Barga is followed meticulously, a diplostreptococcus can be isolated in many cases. This is of diagnostic value and it also can be used in preparing

an autogenous vaccine for therapeutic use which is highly desirable. Abdominal tenderness, especially over the sigmoid, is usually present.

The *x-ray findings* indicating thickening, shortening, loss of haustral markings and (in advanced cases) "lead pipe colon," are valuable supplementary evidence and show the extent of the bowel involved.

*Treatment* must be modified in many instances to suit the individual case. In the acute phases, rest in bed is essential. The diet should be carefully regulated so as to be of ample caloric value, of high vitamin content and free from rough and irritating residue. A careful search for focal infections, and their eradication if found, is important. During the acute stage, or during a severe exacerbation, the use of immune serum is of great value, while vaccine therapy should be used almost routinely in the chronic stage. Autogenous vaccines are preferable but stock vaccines are often used when satisfactory cultures cannot be obtained.

The treatment of chronic ulcerative colitis is essentially medical, but in certain intractable cases, and in the presence of surgical complications, operative interference may be required. Perirectal abscesses demand incision and drainage, while the development of polyposis of any great extent can probably be best managed by electrodesiccation. In extremely severe, advanced and intractable cases, ileostomy may be justified. These patients are poor risks and any surgical procedure involving the intestines should be undertaken with trepidation. In carefully selected rare cases, the formidable operation of colectomy may be considered advisable as a secondary procedure following ileostomy. Appendicostomy, to produce an opening for through-and-through irrigation, has been recommended, but is not in general favor.

Local antiseptic applications, either as irrigations or as retention enemas, are of doubtful value because the inflammatory changes are in the bowel wall and are not influenced by surface applications; further-



more, the trauma incident to administration and distention of the bowel may do more harm than good.

#### BACILLARY COLITIS

*Bacillary colitis*, or bacillary dysentery, is an infectious disease of the lower bowel, characterized by acute onset, often with a chill followed by fever, abdominal pain and diarrhea with passage of blood, pus and mucus. While it is more prevalent in the tropics and subtropics, it is not uncommon in the temperate zones.

The *etiologic agent* is *Bacillus dysenteriae*. Several strains of this organism have been isolated of which those of Shiga and Flexner are most important. In this country children are more apt to be infected by the Flexner strain. The contagion is conveyed directly or indirectly from the excreta of a sufferer of the disease, or from a carrier, to the food or drink of the victim. For this reason the incidence of the disease, like typhoid fever, is in inverse ratio to the effectiveness of general sanitation and personal hygiene.

The *pathology* is essentially that of an ulcerative colitis, with most intensive involvement in the rectum and sigmoid. The early stage is one of acute catarrhal inflammation followed by ulceration. Large areas of mucosa may be destroyed and, with profuse fibrinous exudate, cast off as a pseudomembrane. The acute process is usually limited to the mucosa and submucosa, although in severe cases the bowel wall may be involved. Perforation with peritonitis is a rare complication.

*Symptoms* appear after an incubation period of three to five days and are usually sudden in onset. There may be an initial chill followed by fever, abdominal pain and diarrhea. Blood may not be seen in the first stools but appears with the onset of ulceration. Tenesmus may be severe if the rectum is the site of extensive ulceration. Abdominal tenderness, especially over the sigmoid area, is usual.

The stools are watery and contain blood and mucus; they may vary in number

from a few to twenty or thirty per day and, when copious, may result in a serious fluid loss. Constitutional symptoms including fever, headache, loss of appetite, malaise, weakness and muscular aches and pains vary in degree, depending upon the severity of the infection. In rare cases of fulminating, virulent, infections, overwhelming toxemia and dehydration may produce delirium, collapse and death.

The *diagnosis* is made by identification of the causative organism early in the disease, and by a positive serologic (agglutination) reaction after the first several days. Cultures to identify *Bacillus dysenteriae* may be made from mucoid particles taken from a fresh warm stool, or from scrapings taken directly from the ulcer bases through the proctoscope.

*Treatment* is both general and specific. Isolation and communicable disease precautions, as in typhoid fever, are important. The acute phase of the disease is often somewhat alleviated by the administration of a brisk cathartic such as castor oil or a saline. This clears out the bowel and eliminates much of the toxic material. The diet at first should be nonirritating liquids to which bland solids may gradually be added as conditions justify. Supportive intravenous fluids, with or without transfusions of blood, should be given as the exigency of the case requires. Symptomatic medication should be used freely to make the patient as comfortable as possible. Opiates are highly desirable when the severity of symptoms justify their use. Polyvalent antidysentery serum is considered a specific for this infection. It may be given intramuscularly once or twice daily, or, in urgent cases, it may be given intravenously in smaller doses. The serum should be used in the early stages of the disease. Vaccines, especially autogenous, are preferable for treatment of later chronic manifestations.

#### AMEBIC COLITIS

*Amebic colitis* (amebiasis, amebic dysentery) is a specific ulcerative disease of the colon caused by the parasite *Endameba*

histolytica. It is common in the tropics but may become endemic in temperate climates as was the case in Chicago a few years ago.

The *etiologic* parasite produces the disease while in the motile, or vegetative form, but it is transmitted only while in the cystic stage. Transmission occurs when these cysts, discharged from the intestine, contaminate drink or food consumed by others. Vegetables, such as lettuce, may be contaminated in the field by excreta from an active case, or from a carrier. A food handler, who is a carrier, may disseminate the disease widely. It is probable that 20 per cent of the people who swallow amebic cysts will develop amebiasis, the incubation period of which varies from three weeks to a few months.

*Pathologic* changes are most pronounced in the proximal colon; occasionally the transverse colon, the descending colon or the rectum are affected. The parasite penetrates the colonic mucosa producing tissue necrosis and ulceration. The ulcers do not show typical inflammatory response; leucocytic infiltration does not occur as with bacterial invasion. The ulcers undermine adjacent mucosa, and they may become confluent, leaving only shreds of mucous membrane attached to the bowel wall. In chronic cases, fibrous tissue replacement in the submucosa and muscularis may cause thickening and contraction even to the point of stricture formation. Granulomatous masses occur infrequently and may easily be confused with cancer.

The parasite may penetrate the bowel wall, gain entrance to radicles of the portal vein and be carried to the liver where solitary or multiple abscesses may be formed. Perforation and serious hemorrhage are rare complications.

*Symptoms* are variable. While dysentery is the most common symptom in the acute, virulent type of infestation, in milder and chronic cases constipation or vague abdominal distress may be the outstanding complaint. Dysentery is characterized by passage of liquid or mushy stools which

may vary in number from two or three daily to almost continuous evacuation, depending upon severity of the case. Pus and blood-streaked mucus are usually in the stools. Abdominal cramps and soreness are often present. When the acute stage subsides, a stage of equilibrium between the parasite and host may be reached only to be upset at intervals by catharsis, dietary or alcoholic indiscretions, or general causes. Liver abscess will produce pain in right upper abdominal quadrant, radiating to the right shoulder. Chills and fever, often resembling malaria, may be present. An unproductive cough may be the result of diaphragmatic irritation.

*Diagnosis* in the dysentery stage is made by finding the motile specific parasite in fresh stools or in scrapings from ulcers; in the chronic phase demonstration of amebic cysts is required. Liver abscess should be suspected when an amebiasis patient develops right upper abdominal pain and enlargement of the liver. The initial liver-abscess drainage does not show the parasites but often they can be found in scrapings from the abscess walls. Liver abscess occurs in 15 to 20 per cent of active amebiasis cases.

The *prognosis* is favorable with early recognition and prompt treatment. The development of complications greatly reduces the chance of recovery.

*Treatment.* Ipecac is a time honored drug in the treatment of amebiasis. Its alkaloid, emetine, is preferable and is usually employed in doses of 1 gr. daily administered subcutaneously. It is especially effective in relieving the distressing symptoms of the acute stage of the disease. It should not be used longer than a period of eight to ten days because of the possibility of producing myocardial damage.

Certain arsenicals are considered specific in the treatment of amebiasis; of these, carbarsone is generally considered the most effective. Its dosage is 4 gr. three times daily by mouth, with a rest period after ten days of treatment. Iodoxyquinolin sulfonic acid (yatren, chiniofon, anayodin), an

iodine compound, is also an effective chemotherapeutic agent. It is given by mouth in doses of  $7\frac{1}{2}$  to 15 gr. three times daily for seven to fourteen days. Some clinicians prefer a treatment régime essentially as follows: (1) emetine subcutaneously for seven to ten days to control acute symptoms, followed by (2) carbarsone by mouth for seven to ten days, followed by (3) yatren by mouth for seven to ten days. Then the series of carbarsone and yatren may be continued alternately until the patient is found to be free from the disease as demonstrated by repeated stool examinations.

During the acute stage the patient should remain in bed, and the diet, liquid at first, should be discreetly increased as tolerated, using due care to avoid rough or irritating residue. Symptomatic medication, including opiates, should be used as indicated.

Surgical treatment is limited to urgent complications and to the drainage of abscesses. Patients with amebiasis tolerate surgery poorly and procedures which involve handling the intestines carry a high mortality rate.

#### GRANULOMATOUS INFLAMMATORY DISEASES OF THE COLON

*Tuberculosis* is the most frequent of the granulomatous infections involving the lower bowel. It is a specific infection caused by the tubercle bacillus, and is most frequently seen in patients who have pulmonary tuberculosis with cavitation, the infectious agent being conveyed in swallowed sputum. Adults seem to be about three times more susceptible than children to this secondary manifestation of the disease. Two forms of tuberculous enterocolitis are recognized: namely, (1) hyperplastic, and (2) ulcerative.

*Hyperplastic* tuberculosis, or tuberculoma, is most frequently seen in the ileocolic segment of the bowel. It is essentially fibrous hyperplasia rather than caseation as is seen in the ulcerative form. Fibrosis and contraction may cause ob-

struction of varying degree. It is more frequent in the age group of twenty to thirty years, and is more frequent in Europe than in the United States.

The *ulcerative* form is caused by small, submucous tubercles which undergo caseation and rupture into the lumen of the bowel-producing craters with ragged, undermined margins surrounded by inflammatory areas. Healing and destruction may progress simultaneously. The destructive process usually follows the lymphatics, producing elongated ulcers transverse to the long axis of the bowel. If the rate of destruction exceeds that of healing, large confluent ulcers will occur, and possibly perforation. Perforation may produce peritonitis, or, if omentum or other abdominal structures seal the opening, inflammatory masses may result. Almost all cases of tuberculous ulcerative enterocolitis are secondary to foci elsewhere, usually in the lungs.

*Symptoms* are usually mild or may be absent in the hyperplastic form until some degree of obstruction is produced. Postprandial abdominal pain, often colicky but sometimes dull and aching, is usually the first and most constant symptom. It may be generalized throughout the abdomen or localized in the lower right quadrant. The clinical picture is not infrequently confused with that of appendicitis. Loss of weight is another frequent occurrence and a palpable tumor is frequently present in advanced cases. Less frequent symptoms are vague digestive disturbances and periods of diarrhea or loose stools which may alternate with constipation. Proctoscopy is usually of little value in the diagnosis of tuberculoma because the lesion is rarely within view. X-ray study, after a barium enema, is the most useful diagnostic procedure. The condition may be confused with cancer, which it grossly resembles; but a tuberculoma is usually seen in a tuberculous patient in whom the blood picture seldom shows much change, while cancer of the right colon almost invariably produces a definite, if not profound, anemia.

Ulcerative, tuberculous enterocolitis should be suspected when a tuberculous patient begins to complain of nervous irritability, anorexia or any digestive disturbance. These symptoms usually precede the later symptoms of diarrhea and abdominal pain. Constipation may be present or it may alternate with attacks of diarrhea. Gross blood in the stools is not common, but occult blood can nearly always be detected. The proctoscopic picture, if the ulcers are within view, is often suggestive but may not be conclusive. The ulceration of amebiasis can be excluded by stool examination or by microscopy of scrapings from bases of the ulcers. Biopsy specimens often give valuable information. All clinical evidence, including x-ray, in a given case should leave little doubt as to the nature of the disease.

The *treatment* of intestinal tuberculosis is essentially the treatment of tuberculosis elsewhere. Rest and a high caloric non-irritating diet, with adequate vitamin intake, are fundamental. Intestinal tuberculoma, unless mild, is a surgical disease, and the operation of choice is usually a short circuiting procedure, followed by resection of the diseased portion of bowel, preferably in one stage. Surgical intervention is rarely justified in the absence of obstructive manifestations. Ulcerative tuberculous enterocolitis becomes surgical only when complications, such as perforation, abscess or stricture develop.

*Actinomyces* is a specific, destructive, inflammatory disease, caused by *Actinomyces hominis* (ray fungus) which sometimes invades the lower intestinal tract, the most frequent site being the ileocolic region. It is prone to spread by direct continuity of tissue rather than by the lymphatics or blood stream. Abscesses, which may invade the abdominal wall, followed by draining sinuses or fistulae, are not infrequent complications. In advanced cases the prognosis is unfavorable and the mortality rate is high; in early cases the outlook is more favorable. Large doses of potassium iodide, and perhaps radio-

therapy, seem to offer the best hope of cure. When anatomic localization permits, surgical extirpation probably offers the best chance of cure.

*Syphilis* of the colon and rectum, because of its rarity, is of comparatively little clinical importance. Early lesions, including mucous patches, are occasionally seen about the anus. Gummatous lesions involving the rectum and colon are extremely rare. Benign stricture of the rectum was formerly thought to be of syphilitic origin but it is now known to be a distinct clinical entity.

*Lymphogranuloma venereum* and *rectal stricture* is a specific inflammatory disease caused by a filtrable virus, which is usually transmitted by sexual contact. While it is primarily a genital infection, it is now known to be the causative factor in the vast majority of cases of benign stricture of the rectum.

*Lymphogranuloma venereum* (lymphopathia venereum, lymphogranuloma inguinale, climatic bubo, tropical bubo, strumous bubo, Durand-Nicolas-Favre disease, the fourth venereal disease, the sixth venereal disease, nonvenereal bubo, etc.) and its rectal manifestations are seen most frequently in the lower strata of society in which the incidence of venereal diseases is highest. Negroes seem to be peculiarly susceptible and the age limits correspond generally with the period of greatest sexual activity. Negro women constitute about 80 per cent of all cases.

The primary genital lesion may be so inconspicuous as to go unnoticed. The contagion has a predilection for lymphatics and it spreads along these channels. In the male, the inguinal nodes become involved, producing characteristic buboes; in the female the perirectal lymphatics are invaded and the characteristic rectal manifestations of the disease are produced.

Three *stages* of rectal lymphogranuloma venereum are recognized: (1) Proctitis with diffuse inflammation of the bowel wall usually accompanied by ulceration of the mucosa and the passage of blood, pus and

mucus. Perirectal abscesses and fistulae are not unusual complications. (2) Proctitis obliterans (prestenotic) follows the early proctitis and is characterized by diffuse thickening of the rectal wall which resembles a thick, wet, rough leather tube. Ulceration is more extensive and there is an abundant discharge of a mixture of blood and pus which, in appearance, is not unlike cream of tomato soup. (3) Fibrous stricture of the rectum follows, and is the result of the extensive, inflammatory invasion of the rectal wall. These strictures are usually tubular and extend from just above the anus almost to the peritoneal reflection. Rarely will the process extend upward and involve the sigmoid and descending colon. These advanced fibrous strictures, when palpated through the posterior vaginal wall, feel not unlike a segment of broom handle. The lumen becomes smaller as the stricture progresses and it is not unusual for the rectal canal to be no larger than a lead pencil. At this stage, ulceration is extensive, only fragments of mucosa remaining, and purulent drainage is profuse.

Chronic partial obstruction increases as the stricture develops. Secondary infection, with the obstruction, produces symptoms of toxic absorption.

*Symptoms* become increasingly severe as the pathologic changes progress. In the early stages, frequent passages of mucus, blood and pus occur, accompanied by more or less tenesmus. Perineal swelling and pain are complained of when complicating abscesses develop. As partial obstruction becomes more evident, systemic symptoms such as malaise, meteorism, anorexia, low grade fever, loss of weight and general impairment of health appear. Often there is an almost constant dribbling from the anus of an irritating, excoriating discharge which adds to the patient's misery.

The *diagnosis* is almost self evident if the disease is kept in mind. The possibility of cancer usually can be excluded by clinical characteristics but occasionally biopsy study is required. The Frei test is specific

for lymphogranuloma venereum. This test is based upon the allergic skin response to a small amount (0.1 cc.) of a heat inactivated saline suspension of pus from a lymphogranulomatous bubo (or antigen from other sources) when injected intradermally.

*Treatment* of the disease is not always satisfactory. The use of Frei antigen intradermally once or twice weekly will sometimes delay or even stop its progress in the early stages, but stricture formation is an irreversible process. Mild antiseptic irrigations increase the patient's comfort but have no curative effect. Cutting and dilating the stricture have been disappointing because the stenosis recurs. Application of carbon dioxide snow and the use of heat in the form of diathermy have been beneficial in some cases. When obstructive symptoms occur, colostomy gives immediate and often permanent relief. Complicating abscesses should be incised and drained, and in some cases, fistulectomy is desirable.

#### RADIATION PROCTITIS

This is a lesion, sometimes called factitial proctitis, caused by the destructive action of radioactive energy, most frequently seen in women who have had radium therapy for cancer of the cervix uteri. It begins as an edematous thickening of the rectal mucosa, almost always on the anterior wall opposite the site of radium application. If the amount of radiation absorbed has been sufficiently small, this reaction may subside gradually without actual tissue destruction. As a rule, however, the stage of edema is followed by necrosis and ulceration. The mucosa and submucosa slough away, leaving a pearly white fibrous base sharply circumscribed by reddened, hyperemic mucosa in the margin of which the blood vessels stand out prominently. This hyperemic area bleeds easily on slight trauma. The ulcer may be small and involve only the anterior wall or it may extend entirely around the circumference of the bowel.

*Symptoms* usually appear three or four weeks after radiation therapy although several months may elapse before the condition becomes apparent. The symptoms are those of ulceration and bowel irritability. The first complaints are usually discomfort or pain and the passage of blood and mucus. Later, tenesmus may become distressing. With a history of radiation therapy and the characteristic appearance of the ulcer there should be little difficulty in arriving at the diagnosis.

*Treatment* in uncomplicated cases is palliative. Rest in bed and warm, cleansing irrigations are helpful. The tenesmus, if severe, may require an opiate, but soothing

instillations of warm olive oil or of starch gruel often give relief. The patient should be instructed to take a warm, plain water enema for its cleansing effect after each evacuation. The direct application of 1 or 2 per cent gentian violet solution or of balsam of Peru through the proctoscope every second or third day may be beneficial. If pain becomes intractable or if stricture develops, colostomy may be required. Posterior proctotomy for stricture is usually unsatisfactory. It relieves the stenosis only temporarily and subsequent contraction is almost certain. If the stricture is severe enough to warrant surgery, it is probably better to do a colostomy.



"ITCHING" sensation of the skin may be very distressing. It may be associated with an obvious dermatitis or other skin lesion, and then cause and effect are definite. There are, however, many cases where there is no visible cause for the sensation, and then it is termed "pruritus."

# PROCTOSCOPIC RECOGNITION OF RECTOSIGMOIDAL AND SIGMOIDAL LESIONS

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THE recognition of rectosigmoidal and sigmoidal lesions is, or should be dependent upon direct or indirect visualization. Anamnesis as related to diseases of these areas is helpful but cannot be depended upon to too great a degree. When the patient's statement that he has experienced bleeding from the anorectal region and that he has hemorrhoids, which is the most common anorectal complaint, is taken too literally, it often results tragically for the subject and proves to be embarrassing to the attending physician. Too often the physician agrees with the patient's diagnosis and without benefit of examination palliative measures are advised. Bleeding is common to many lesions in this area. It is the most frequent symptom complained of by people who have hemorrhoids and also those who have cancer of the lower bowel. If adequate search consisting of thorough sigmoidoscopic examination, and roentgenologic examination if indicated, are not done, then valuable time may be lost in attacking diseases of this area. The symptoms of cancer in this region are the symptoms of complication. Frequently, before subjective symptoms become severe enough to cause the patient with cancer of the colon to seek advice, there is a visually recognizable lesion present. This argues for more frequent use of the sigmoidoscope, which in proper hands can reach past the area where the greater number of malignant lesions of the large bowel are located.

Direct visualization obtained through the skillful use of the sigmoidoscope is of course the most certain means of diagnosis of lesions within its reach. The next best, and an adjunct of increasing help and specificity, is indirect visu-

alization by means of roentgenoscopy and roentgenography. Bacteriology is of course an important aid in ulcerative lesions. Sigmoidoscopy should be employed, however, in all cases for frequently two different entities may be present at the same time. Great strides have been made in roentgen diagnosis of diseases of the large bowel since the advent of the contrast enema and the lateral position for visualizing the lowermost portions of the colon and rectum. The mutual aid and the overlapping of the fields of the proctoscopist and the roentgenologist are not to be underestimated.

Through some chain of events it has so come about that probably the most serious and most frequent organic changes occurring in the colon are within visual reach of one trained in the proper use of the sigmoidoscope. These changes can either be diagnosed at the time of visualization or important aid can be given to assist in their final diagnosis. It is doubtful that much information can be gained by the occasional peeper through the short, unlighted anoscope or rectoscope, which is the usual limit in armanentarium of proctoscopic instruments. If one is to accept the responsibility for diagnosing and treating diseases of this area, it is necessary to have as complete a knowledge of this field as is required of the cystoscopist and the bronchoscopist in their fields. It is true that occasionally the use of the usual poorly lighted rectoscope which is not equipped for inflation, in an unprepared bowel, may reveal a carcinoma or even a small polyp in the rectum. Much, however, is left to chance. It may easily fail to show an early lesion and this is the stage at which diagnosis is most important if the

patient is to have the best chance of recovery.

It is first of all important that one be totally familiar with all variations of size, color, shape, etc., of the so-called normal bowel; for unless one is entirely familiar with the normal bowel and its non-pathologic variations, it will be difficult to know the abnormal in its early form.

Obviously, it is also important that one be equipped properly for the examination of the areas under discussion. Few, if any, physicians doing a general practice have added bronchoscopes or cystoscopes to their equipment, yet there are perhaps still too many who are satisfied if the passage of a rectoscope into an unprepared bowel fails to reveal anything. Being equipped properly entails the possession of an instrument of correct length and it is important that this instrument be sufficiently lighted. It is just as easy to visualize the rectum through a sigmoidoscope as through a rectoscope and the sigmoidoscope has the advantage of enough length to reach the sigmoid where such a large number of changes take place. The question of where the light is placed in relation to the ends of the instrument is one of choice provided that direct and not indirect light is used. It has been the writer's observation, that on numerous occasions decisions made with reflected light, or a proximally lighted instrument have been proved erroneous when a distally lighted instrument was used. It would be reasonable to assume that the closer an adequate light is to the object, the better the definition. Along with the proper instrument, an inflating bulb should be used freely. Frequently in all positions, but to a lesser degree in the inverted proctoscopic position, the bowel is found to be collapsed when the instrument is inserted and thus it is difficult to see between the folds and for this reason, small lesions and early changes in the mucosal pattern may be missed. With the inflating bulb, the bowel wall can be smoothed out and readily studied.

The position of the patient for examination is also one of choice; however, it appears evident that the inverted position, best obtained on a proctoscopic table, has many desirable features. This position allows the abdominal contents to fall away from the pelvis and the lower bowel is, by reason of this, straightened out as much as its anatomical attachments will allow. The introduction of the instrument allows air to pass into the bowel and in this position this alone frequently causes the bowel to balloon out. This factor and the fact that the remainder of the abdominal contents are not pressing on the wall of the lower bowel, tend to smooth out the folds so that inspection of the bowel wall is more adequate. Even in this position, the inflating bulb is often necessary for a clear cut view of all of the surface area and its judicious use is of great aid. Certainly it is more desirable to visualize an area directly than indirectly. Thus, although fluoroscopic study and roentgenograms are of great aid in the diagnosis of disease of the lower colon, it is self evident that a direct view, by one properly trained in the use of the sigmoidoscope, is of far greater value than an indirect view by means of roentgen rays.

It is doubtful if any great value can be placed on digital examination, although this should always precede instrumentation. The knowledge obtained by digital examination, as to whether or not there may be a growth or an obstruction within reach of the finger, the presence of which would necessitate extra care in the introduction of the instrument, is useful. The tone of the sphincter muscles, and if a tumor is present, whether or not fixation has taken place can also be determined. The degree of fixation, however, can be determined about as readily by pressure of the instrument against the growth. It is true that to one thoroughly trained in anorectal diagnosis "the feel" of a carcinoma of the lower bowel is almost diagnostic; however, "the sight" of one is definitely more certain.



The sigmoidoscopic recognition of lesions of the rectosigmoid and sigmoid is dependent, therefore, on a clear unobstructed view of these regions. To obtain this, the lower bowel should be thoroughly cleansed. This is best obtained by means of nonirritating cleansing enemas given a few hours before examination. It is of no value and often a disadvantage to purge the patient. If irritating enemas are used, such as those which contain soap, the mucosa may be inflamed and a false impression gained.

With the patient in the chosen position, a digital examination is done for reasons stated above. The sigmoidoscope with obturator in place is introduced only through the external sphincter mechanism. When this point is reached, the obturator should be withdrawn and further passage accomplished under direct vision. At this time fecal material or retained material from the enema may be encountered. Here it is of inestimable value to have an adequate suction to remove the material through the sigmoidoscope. The passage of the scope under direct vision gently carried to its fulfilment, should never cause a bowel to be perforated. Even though it may be a point of pride with many proctologists to be able to follow the circuitous route from the rectum to the sigmoid without the aid of an inflating bulb to balloon out the bowel, the one using the inflating bulb will be able better to visualize small lesions which might be hidden by folds of the mucosa and the time consumed in the examination may be materially lessened.

It is good practice to concentrate at first on inserting the instrument its full length as quickly as possible and do a detail study as the instrument is being withdrawn. If, with an apprehensive nervous patient, too much time is taken up as the instrument is being inserted, the patient may begin to strain and it may become impossible to pass the instrument its full length.

The recognition of diseases, such as hemorrhoids, fissures, fistulas, etc., which occur in and around the anorectal junction do not

come within the scope of this paper. Such diseases as chronic ulcerative colitis in its several forms, one-third of the cases of amebic infection which have lesions that are directly visible in the lower bowel, lymphopathia venereum, tuberculosis, malignant lesions, etc., all are seen most frequently in the rectum but may occur in or extend higher in the large bowel. Such clear cut descriptions of all of these diseases have appeared in the medical literature so often that the writer considers it unnecessary repetition to detail their symptoms and their visual and roentgenological characteristics.

It is the intention of the writer to encourage the more frequent use of the chief diagnostic aids in the diagnosis of lesions of the colon and rectum and to make a plea for the more careful differentiation of organic and functional disease of the colon. He wishes to reiterate only the findings in some of the less commonly described lesions which are being found in increasing numbers in this area. That these lesions are being found more often is due, it is thought, not to so much an actual increase of these lesions but to the fact that the examination of this area is done more frequently and more skilfully.

It has not been the writer's observation that inflammatory lesions of the lower bowel are very common. Vast numbers of patients will say, or say that they have been told, that they have colitis. Careful questioning will bring out the fact that what is usually meant is some alteration of bowel function usually brought on by "doctoring the bowels." This results in vague complaints of gas, abdominal soreness, and the vicious circle of taking something to force elimination, with the result that they become chronically unwell and are good subjects for the "colon irrigators" and such. Careful examination of most of these poor unfortunates fails to reveal anything of an inflammatory or an organic nature.

The most frequent lesions the writer has encountered in his practice which is solely proctology, other than lesions which

occur in and around the anorectal ring, are polypoid lesions of the rectum, rectosigmoid and sigmoid. These have been seen in approximately 5 per cent of the cases observed, all of which have been examined under as ideal conditions as can be obtained. The size has ranged from a few millimeters to several centimeters. Most of these lesions are asymptomatic and are incidental findings resulting from a thorough sigmoidoscopic examination on all patients, regardless of their chief complaint.

There is no typical history given by patients who are found to harbor a polypoid lesion in this region. The majority of the writer's series of polypoid lesions have been incidental findings as stated above. These patients present themselves with complaints ranging from pruritus ani to violent tenesmus. The symptoms presented by such lesions are usually in direct proportion to the size and location of the tumor.

Small sessile lesions can hardly be suspected of presenting symptoms other than bleeding. Bleeding from such a lesion may accompany bleeding from the region of the anorectal ring. Unless careful search is made of the area through which a sigmoidoscope may be passed and if indicated a contrast enema done, it is evident that these lesions may be overlooked and the whole blame be laid on the anorectal region, until the polyp has reached sufficient size to give other symptoms of itself. That this has not infrequently been done is evidenced by the fact that such a large number of cases with even a full-blown carcinoma of the lower bowel give a history of having received treatment for anorectal lesions. After recovery from the anorectal treatment they still have more or less the same complaints and a more thorough examination reveals an additional lesion or lesions. Had these cases been thoroughly examined and given the benefit of a sigmoidoscopic and/or a roentgenological examination, it might have been possible to avert this situation.

The pedunculated lesions by reason of their being pedunculated more often give rise to symptoms. This may be due to several factors. They get in the fecal stream, are irritated and traumatized more readily than is the sessile group, and thus the symptoms of bleeding may occur earlier. Tenesmus resulting from the peristaltic waves trying to expel the mass with resulting traction on the mass, may cause pain as well as bleeding. A patient whose history includes such complaints as tenesmus, the occasional passage of blood-stained mucus, vague pains in the abdomen or back, a frequent urge to defecate usually with little results, and a feeling at times as if the rectum were full, with no result from attempts to empty it, should be thoroughly investigated, sigmoidoscopically and with the contrast barium enema. These symptoms may be the warning of a mass fixed low enough so that it can be visualized directly; it may be either a pedunculated or a sessile mass which at times prolapses down into view; or it may be a mass attached too high to be visualized directly and should be searched for by means of a contrast enema. One should guard against the too frequent willingness to be satisfied that what anorectal lesions are seen on casual examination, account for the complaints of the patient.

Polypoid lesions, although innocent appearing at times, frequently show microscopic changes ranging from hyperplasia or anaplasia to frank malignancy. Of the writer's series approximately 70 per cent showed such variations from the normal. It appears illogical to say that only a certain percentage of these growths become malignant when so much incriminating evidence has been piled up against them. An analysis of the writer's series of polypoid lesions leads one to assume that if an individual has a polypoid lesion of the colon or rectum, and lives ten years, his chance of having a carcinoma in the corresponding location is too great to be minimized.

The polypoid lesions which are found to be benign are most frequently adenomas; however, lipomas and fibromas occur infrequently as intraluminal tumors. As a rule types other than the adenomas occur higher in the colon, are pedunculated and for this reason are more prone to prolapse causing more or less a degree of intussusception with resulting symptoms. At the time of sigmoidoscopic examination, these masses may have returned to their original position and will not be seen. Their diagnosis then, becomes dependent on visualization by roentgen examination. This is best accomplished by a fluoroscopic observation of a barium enema followed by a contrast enema.

Not infrequently patients present themselves with complaints of fulness in the rectum, of infrequent defecation, others of frequent emissions of small amounts of bowel content, burning, backache and other vague rectal symptoms and are found to have a mass in or above the rectouterine or rectovesical space. This can not always be felt by digital examination; however, the passage of the sigmoidoscope into the rectosigmoid, or higher, is impeded by a mass which impinges on the lumen thus fixing the upper rectum and rectosigmoid so firmly that the passage of an instrument above this is impossible. The finding of such a mass is added evidence of the importance of routine sigmoidoscopic examination because it frequently indicates primary disease in other parts. The mass, may be due to implants from malignant disease of the stomach, small bowel, colon or genitourinary tract. Not all of these lesions are secondary growths from malignancy in other locations. They may be the result of inflammatory or benign lesions of the gastrointestinal, urinary or genital organs, impinging on the rectal wall. The finding of such a lesion means that careful investigation should be made of the other systems. The secondary malignant lesions are usually localized anteriorly in the cul-de-sac and are usually in one mass. The secondary inflammatory

manifestations may be made up of several masses, giving the lumen a nodular appearance and are not as universally located anteriorly as are the malignant implants.

One of the writer's four cases which presented a great number of nodular masses protruding into the lumen of the rectum and rectosigmoid, over which the mucosa was intact, was found to have a tuberculous peritonitis on exploration. The biopsy from one of the nodules taken through the rectal wall, showed only inflammatory tissue. The remaining three patients did not submit to operation, but it is believed that probably all were tuberculous.

Some patients who seek medical advice on account of changes in bowel habit, usually a frequency of stool, are found to have a condition in their lower bowel which when viewed through a sigmoidoscope, is difficult to describe. Usually these patients complain of anorexia, gas, an increased number of stools which are usually soft and mushy if not watery, vague abdominal pain and soreness, muscular pains in the legs and nervousness. These individuals are frequently on a self imposed, inadequate diet, have a slick tongue, are nervous and very introspective and frequently have generalized tenderness to palpation of the abdomen. The lower colon and rectum, when viewed through a sigmoidoscope, are found to be rather atonic and relaxed. The mucosa is moist, reddened, although definitely not ulcerated, and very smooth. The roentgenogram of the colon reveals nothing as a rule, but on following the barium meal through the small bowel, changes are frequently seen in the mucosal pattern which leads one to believe that a dietary deficiency is present. It is perhaps true that some of the ulcerative lesions, which one sees localized in the lower colon but may be found in other parts of the colon by roentgenograms, in which no bacterial cause can be found, are advanced stages of this same process. These lesions are limited to definite segments of the bowel

and do not present the same picture as thrombo-obliterative colitis which has been so frequently described and which is undoubtedly bacterial in origin. Why this lesion, if it be the result of deficiency, should be localized to segments of the colon is not now known.

The ability to distinguish between organic and functional disease of the large bowel is the most necessary part of the armamentarium of those who examine this portion of the body. The diagnosis colitis is still probably one of the most abused in medical literature. The term colitis as it is commonly applied, is closely akin to the miasmatic group of diseases and too frequently it is the waste basket into which is thrown many of the vague complaints referable to the abdomen with or without change in bowel habit. There is a vast army of unfortunates being treated solely on this basis. Many have never had the benefit of a thorough colonic examination. They are frequently on inadequate diets, either prescribed or self imposed. They are already "doctoring their bowels"

or are advised to do so either with laxatives or lavages or both, until the normal physiology of the bowel and their nervous system are so upset that they are burdens to themselves and to their families. Exhaustive studies of those individuals are essential. In the face of negative results, it requires tact and patience to convince these sufferers that their symptoms, as related to the colon, are not the result of organic disease but the result of a disordered physiology due either to disease in other parts, or are the result of treating symptoms which are not related to the colon or are functional in character. To stop this type from their use of laxatives, mineral oils, enemas, and fadistic diets, is often a long and arduous task.

The skilful use of the sigmoidoscope should become more general, for often only by its use can the presence of early organic disease be determined or ruled out. Early diagnosis of colonic lesions is important and can be easily made by skilful use of the diagnostic aids at our command.



# ANAL FISTULA AND ABSCESS

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THE term, anal fistula or abscess, is not an accurate anatomical description of the lesions usually classified under these titles. In most instances fistulas or abscesses of this type have their origin and primary opening in one of the crypts of Morgagni, which are located in the terminal-most part of the rectum, and therefore the lesion is not strictly anal in character. The external or secondary openings may be anywhere in the skin adjacent to the anus. Regardless of terminology this is the lesion present in approximately 95 per cent of all patients presenting fistulous openings about the anus. While this is usually the case, it is important to remember that occasionally an abscess or fistulous opening in this region may have its origin in some distant point, as the female organs, the prostate, seminal vesicles, posterior urethra, in an infected sigmoid diverticulum, Pott's disease, pelvic infections, perirectal infections, perirectal cysts, appendiceal abscess, and other less frequent conditions.

As has been stated, the origin of a fistula or abscess, commonly termed an anal fistula or anal abscess, is usually from an infection involving a crypt of Morgagni. Tucker and others have pointed out the presence of preformed ducts connecting with the base of these crypts and extending outward into the perianal tissues. He believes the infection develops in these preformed ducts rather than in the crypts themselves. I have not been able to convince myself that this is true, at least not in all cases. Tucker has shown microscopically that these ducts do exist in certain individuals, but I am inclined to believe that further study will show that these ducts are a vestigial remnant, that their presence or absence is as variable as is the case of pilonidal sinus, and that they

are not present in all persons. At least I believe that an infected crypt of Morgagni is most often the cause of perianal abscess formation. There is certainly a great variation in the crypts of Morgagni. In some cases these crypts are represented by the merest depression in the rectal mucosa with no pouch or pocket at their terminal ends. In others there is a definite pouch or pocket at their caudal termination. This pocket may be a centimeter or more in depth, extending beneath the epithelium of the anal canal caudal to the pectinate line. These pouches being the terminal portion of the crypts of Morgagni, are lined with rectal rather than anal epithelium. There is no doubt that an anal fistula occurs much more frequently in persons having well developed crypts with deep pockets at the caudal end, than in those in whom the crypts are rudimentary and the pouches are very small or absent.

The usual sequence of events in the formation of an anal fistula is infection of the mucosa lining the crypt, extension of the infection through the bowel wall, the formation of a perianal abscess and then rupture or incision of the abscess, which completes the fistula. The only instances in which infection of the crypt does not precede abscess formation, is when there is perforation of the crypt wall by a foreign body. This is a fairly common occurrence due to the ingestion of sharp spicules of bone, toothpicks, etc. While more than one crypt is often infected, usually only one is involved in an infective process severe enough to extend through the bowel wall. For this reason, at operation, a fistula-in-ano is seldom found to have more than one internal opening. Occasionally, a perianal abscess may occur without actual perforation of the bowel wall. In this case, exten-

sion is directly through the rectal wall or by way of the lymphatics. When abscess occurs and a fistula does not result, it is either due to infection spreading in this manner or there has been a very small perforation, which healed after the abscess was drained externally. In the vast majority of instances there is a well defined opening through the bowel wall and a fistula results. The immediate causes of the extension of the infection through the viscus varies. In some cases the infection may simply gradually progress until perforation occurs. In many instances, I believe, the cause is some unusual traumatization, occurring in a crypt already weakened and made friable by previously existing infection. This trauma may be caused by the passage of a large hard stool, the excessive muscular action of repeated defecation due to an acute diarrhea, or some external or instrumental injury. The rapidity of formation of the abscess, once the infection has extended to the perianal tissue, depends upon the type and virulence of the organism and perhaps the resistance of the host. These abscesses usually show mixed infection, although occasionally an almost pure culture of *Bacillus coli*, a short chain streptococcus, the tubercle bacillus or other organisms may be found. In most instances, once perforation of the bowel wall occurs, the abscess develops within a few days, with the usual redness, heat and pain. There is, in varying degrees, a rise in temperature, a leukocytosis, a feeling of malaise and often some muscular aching. Pelvic and inguinal lymph-nodes may be involved. In rare instances the infection may be of such virulence that it quickly spreads throughout the body and death results. I recall one case in which death occurred within three days and there was involvement of many lymph-nodes, multiple abscesses of the lungs and liver, and a generalized blood stream infection. The other extreme is the presence of a practically nontender area of induration adjacent to the anus which is the first symptom noted by the patient. This

hardened mass gradually approaches the skin surface, slowly increasing in size, finally becomes slightly reddened and tender and eventually ruptures or is incised. If spontaneous rupture is allowed to occur, the entire cycle may take several weeks. This is the description of an abscess caused by an organism of extremely low virulence. This description also coincides with that caused by the development of an abscess due to the tubercle bacillus. The difference is, that with a pyogenic organism, rupture or incision of the abscess discloses the presence of ordinary pus, while in a tuberculous condition, unless contamination by other organisms has occurred, discharge is thin, watery and flocculent.

Occasionally, abscesses originating in a crypt of Morgagni do not rupture perianally. In this event, one of two types of syndromes may develop. In the first, an indurated area is felt adjacent to the anus. This is more or less sensitive and may or may not, present evidence of superficial inflammation. After a time these symptoms disappear spontaneously, and usually rather suddenly. This is the result of the abscess having drained into the rectum through the primary opening. In the other variety the patient notes a deep-seated soreness in the anal region but without external evidence of induration or inflammation. Soreness is increased by pressure or contracture of the muscles in this region. These symptoms also disappear spontaneously when the abscess drains internally. In either case the cycle may repeat itself many times without the abscess rupturing externally. In some instances, external rupture eventually may occur, or the abscess present itself so superficially that it is incised. This type of abscess and sinus not infrequently acts as a definite focal infection, serving as a spark plug for a more distant infectious process.

While most abscesses and their resultant sinuses and fistulas result from infections in the crypts of Morgagni, such conditions can and do result from infections in the

wall of the anal canal. The most common infectious processes are chronic fissure-in-ano, or recurrent anal cracks and abrasions. A congenitally small anal canal or an acquired anal stenosis predisposes to these conditions. The abscess resulting from infection in this region is usually more superficial as is the resulting fistulas. For this reason operation upon fistulas of this origin does not necessitate the division of the external sphincter muscle as often as in the case of fistulas originating in a crypt of Morgagni.

When it becomes necessary to operate upon an abscess or fistula, it is a matter of importance whether the infectious process has reached the ischiorectal fossa by extension *through* the space between the internal and external sphincteric muscle, or has reached it by extension *around* the external sphincter. In the former case, the external sphincter must be divided in order to cure the fistula; in the latter, division is not necessary. The division of the external sphincter is not as vital a matter as is sometimes supposed, since it actually has little to do with what is loosely called "control of the bowels." It is a voluntary muscle which has to do with the completion of the act of defecation. It aids in the final expulsion of the terminal portion of the stool in a clean manner. In the case of diarrhea or an unusual accumulation of gas it is valuable as a voluntary *accessory* sphincter, and thus has a high degree of social importance. If it is severed, the process of cleansing after defecation is much more difficult and washing is often required. For these reasons if the external sphincter can be spared it is advisable to do so, although most patients can carry on in a highly satisfactory manner even though it is divided. The division of the internal sphincteric ring is not necessary in cases of anal fistula, although it may be in the more complicated and deeply seated fistulas.

Whether or not the infectious process reaches the ischiorectal fossa between the sphincters or more superficially around the external sphincter, depends in many in-

stances upon anatomical variations in the anal region. It is recalled that the anal canal begins as a dimple in the ectoderm which grows inward to meet the endodermal hind gut. Fusion of these organs occurs about the eighth week of embryonic life. At the point of fusion is the pectinate line, the juncture of the squamous epithelium of the anal canal and the columnar epithelium of the rectum. It is at this point that the pouches of the crypts of Morgagni extend downward underneath the upper portion of the anal canal. The length of the average anal canal is one and three-tenths inches, and its entire length is lined with squamous epithelium. Anal canals vary in length from one-half to two inches, so that in some cases the rectal epithelium may extend downward through the canal almost to the anus. In this case the pectinate line is almost at the anal orifice and the squamous epithelium extends upward only a small fraction of an inch. In these individuals when the margins of the anus are slightly retracted, the red velvety rectal mucosa is plainly visible. This means that the pockets at the lower end of the crypts of Morgagni are situated low in the anal canal just above the anal orifice. (Fig. 1, Part II.) It is evident that infection occurring in a crypt in this position would produce a superficial abscess and one which would not likely involve the external sphincter muscle.

There is also considerable variation in the sphincteric musculatures, which also has to do with the location of abscesses and fistulas occurring in this region. The first is the relationship of the internal and external sphincteric rings. (Fig. 1, Part I.) These bands may be quite closely incorporated together. (Fig. 1, Part IA.) They are always distinct upon dissection, but by palpation it is often difficult to feel a line of demarcation between them. In other individuals the rings are quite far apart. (Fig. 1, Part IB.) A very definite space or depression can be felt between them and each can be palpated as a separate entity. When the two bands are closely incorporated, it is evident that an infection would be less

likely to extend between them. Finally, there is a great variation in the relative position of these muscles to the anal canal

pockets of the crypts of Morgagni are situated at the upper margin of a long anal canal, and the sphincter muscles surround

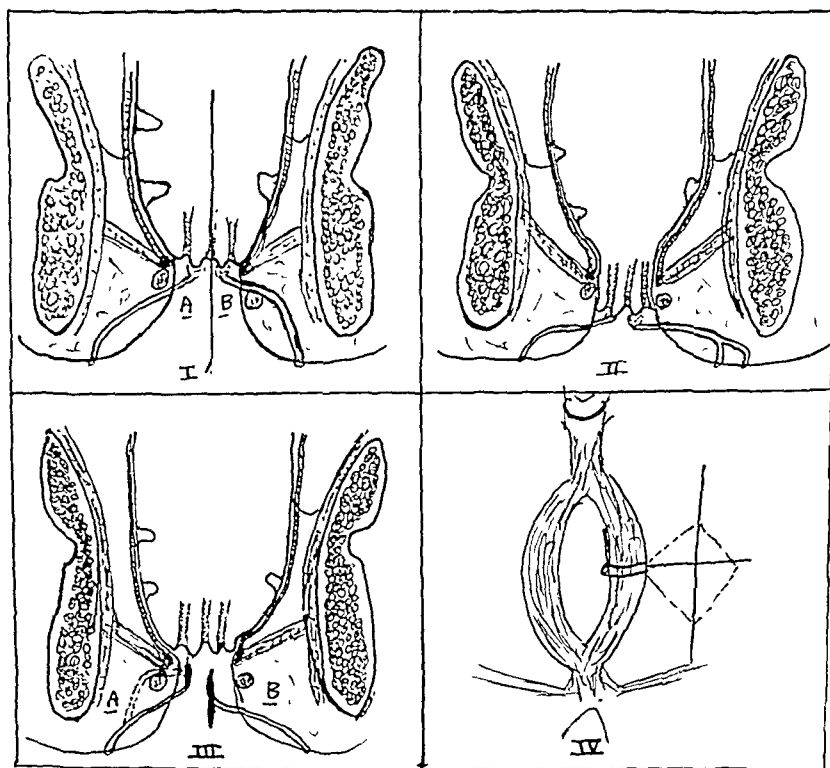


FIG. 1. Diagram of anatomical variations which often influence the involvement or noninvolvement of the external sphincter in anal fistulas; proper method of draining anal abscess. I, termination of crypts cephalad to sphincteric rings: (A) sphincteric rings closely approximated; (B) sphincteric rings widely separated. II, termination of crypts caudad to sphincteric rings. Showing closely approximated and widely separated types. III, fissure-in-ano: (A) fissure arising from crypt; may cause fistula involving sphincter; (B) fissure usually arising from trauma near the anal margin; almost never causes fistula involving sphincter. IV, proper method of draining perianal abscess. Dotted lines indicate amount of skin and overlying fat to excise to prevent too rapid closure of wound.

and crypts of Morgagni. In some cases the external sphincter (occasionally also the internal) surround the anal canal at its very lower-most end. In fact, the muscle stands out as a cord-like band plainly bulging through the perianal skin external to the anus. In other individuals nothing can be seen externally and the muscle is not visible through the skin, even though it is contracted voluntarily. Palpation will reveal the muscle deeply placed and surrounding the anal canal high above the anal orifice.

If we take two extremes as an example, it is perfectly evident what will occur. If the

the canal near the anal orifice, infections arising in such crypts are well above the sphincter muscles. As the infectious process burrows downward it is likely to spread laterally through the space between the sphincters. This is almost certain to occur if the sphincteric rings are rather widely separated, less likely if they are closely approximated. If the reverse is true, i.e., the sphincter is situated high and the crypts low in the anal canal, infection occurring in such crypts is actually below the sphincter and hence the infection will spread laterally without involving the muscle. (Fig. 1, Part II.) Between these



two extremes lie the anatomical variations which influence the manner in which infectious processes extend from the crypts of Morgagni to the ischiorectal fossa. These anatomical variations, plus tension determines whether the infection spreads above or below the external sphincter, which in turn, determines whether or not external sphincter must be divided in operating upon an anal abscess or fistula. In special instances, other factors may have a bearing upon the manner of the spread of the infection, but in general we believe these to be the most important considerations of a general character.

The location of the infected crypt usually has a direct bearing upon the location of the subsequent abscess. In the case of infection of lateral crypts, the abscess is most likely to form directly in the adjacent ischiorectal fossa. If the posterior crypt is involved the abscess usually forms in the midline posteriorly, or a little to the right or left of the midline. Anteriorly it may be either in the midline or slightly lateral. Fat has little resistance to infection, and once the infection has reached the ischiorectal fossa, there is a further tendency for this process to spread. This extension may simply be through the fat of the one fossa, or it may extend posteriorly underneath the anococcygeal tendon and involve the adjacent fossa. This same tendency to spread may occur anteriorly, and in this location, extension is seen more often in the female than in the male. Anteriorly, the extension is usually along the transversus perinei muscle. Almost invariably the extension of the process ceases the moment the abscess is incised and tension relieved. For this reason, contrary to the belief of many, we believe that the earlier these abscesses are drained, the better. In our opinion it is a mistake to treat the condition expectantly and wait for the abscess to "point." To do so only invites the formation of a larger abscess cavity, the extension to more distant points and greater tissue destruction. It has been our custom for the past twenty years to drain

these abscesses the moment we could be sure that pus was present, even though there is no external redness of the skin or other superficial evidence of abscess formation. We have had no occasion to regret it. In most instances in which we have been confronted with extensive and complicated fistulas, the patients have failed to see a physician and the abscesses finally ruptured, or they were treated by some physician with hot packs and Sitz baths, rather than immediate drainage.

When an abscess is seen, it is always a question as to whether or not a primary or internal opening is present, although it should be assumed that one is present until proved otherwise. This can often be determined by dilating the anal canal and lower rectum with a bivalve speculum, and carefully examining the rectal crypts with a blunt hook. Often the tip of a hook can be passed through the opening in the infected crypt into the abscess cavity, or pus can be seen oozing into the crypt from the abscess. If the opening is not found in this manner, the abscess is opened and gentle probing of the cavity may reveal an opening into a crypt. In both instances, examination should be done carefully and gently, so no opening is made where none existed. If no opening is found, the surgeon should be content with draining the abscess. If an opening is found, it is a question of whether or not the intervening tissue should be divided and the entire operation completed, or whether the abscess should be drained and the fistula operated upon at a later date.

Our course is determined by the following factors: In all cases in which the tract lies below the external sphincter, we complete the operation without delay. If the abscess is small, even though the sinus is above the external sphincter, we also complete the operation immediately. On the other hand, if the abscess is large and for this reason the margins of the wound gape widely after incision, thus widely retracting the cut margins of the sphincter, we simply drain the abscess. Later after

the cavity has contracted, the sphincter is divided. The smaller cavity retains the cut margins in much closer apposition, and we believe there is less final deformity than if the operation is completed when the abscess was drained. All large abscesses should be widely opened by a crucial incision, and one limb of the cross should be carried down to the outer margin of the sphincter (Fig. 1, Part iv.) It is our custom in the case of large abscesses to remove a portion of the overlying skin which prevents too rapid healing of the incision and insures adequate drainage without daily packing. By carrying one arm of the incision to the outer margin of the sphincter, only a short tract passing under the sphincter to the crypt is left to be divided subsequently. A seton is passed through this tract and tied around the sphincter. This keeps the tract open and acts as a guide at the time the muscle is divided. This final step of the operation is so simple that it usually can be done in the physician's office with the aid of a small amount of local anesthesia.

In many instances the physician does not see the patient in the abscess stage but only after the fistula is present. Sometimes this is many years after formation of the original abscess. Buie states that 69 per cent of his patients had had their fistula more than one year and 22 per cent for more than nine years. In cases of long duration, there is ordinarily a history of repeated attacks. The usual story is that the fistula heals externally and discharge ceases. Then after varying periods of time, some tenderness and induration is noted and there is a return of the discharge. This process may be repeated many times. In most instances the recurrence is in the same location and the discharge is at the site of the original opening. In other cases the infection breaks through the walls of the original cavity and rupture occurs externally at a different site. The number of external openings which may be developed in this manner is almost unlimited. One of our patients had forty-two external openings. Regardless of the

number of external openings, there is usually but one internal or primary opening. The external openings are merely caused by burrowings of the infectious process. All connect at some point with the original sinus. While anal fistulas almost invariably have a single internal opening, multiple internal openings are often present in fistulas arising higher in the rectum. These fistulas usually result from infectious processes above strictures which may occur from any inflammatory process, but are frequently seen in the female following lymphopathia venerea infection. They also occur in cases of actinomycosis, advanced carcinoma, or occasionally in tuberculosis.

While in anal fistula only one internal opening is usually present, the ramification and extent of the tract (or tracts) before the surface is reached is unpredictable from external appearances. In some instances the extent cannot be determined by preoperative examination. According to Salmon, if a transverse line is drawn across the anus midway anteriorly-posteriorly, any fistula whose external opening is posterior to this transverse line will have its primary opening in the midline posteriorly. Any fistula having its external opening anterior to this line, will have its internal opening directly into the nearest crypt. This is not an invariable rule but it is usually correct and gives a good clue as to where the internal or primary opening may be.

The primary requisite for the successful operation for fistula is that no tracts or branches of the fistula be overlooked at the time of operation. To prevent this, several methods are advocated to determine the extent and location of the tracts before operation is begun, and also to aid in following the tracts at the time of operation. The two most widely used are the injection of bismuth paste, or soda iodide solution, followed by x-ray and the injection of various dyes. In anal fistula neither of these methods has been of any particular help to us. If there is a single tract, it is easily followed; and if there are lateral

branches present, they are frequently not penetrated by the bismuth or sodium iodide, and hence the surgeon may be confused rather than helped by the x-ray plates. We do find the injection of bismuth or sodium iodide to be of help where the site of the origin of the fistula is in some distant place, as in a sigmoid diverticulum, or where there is a connection with the bladder or other viscus. Various dyes are also injected in order to stain the tract, determine the site of the internal opening and enable the surgeon to follow the tract more readily at time of operation. Again we think this unnecessary, as anyone familiar with this type of surgery should be able to follow the tracts by watching the granulation tissue lining the sinuses and carefully probing and palpating the tissues. The injection of any substances into the fistulous tract is not without danger of perforation of the tract and spread of the infection. The injection of dyes is also open to the same objection as the use of bismuth and sodium iodide, i.e., all accessory tracts are not penetrated. If a fistulous tract is injected, it should be done gently and without pressure. Hydrogen peroxide or other gas-forming solutions should never be added to the dyes. There are several methods whereby the surgeon can gain some preliminary knowledge as to the nature of a fistula. If possible, the location of the internal and external openings should be determined. The external opening or openings are usually apparent. If the anal canal and lower portion of the rectum can be dilated with a bivalve speculum, inspection of the crypts and anal canal will often reveal the internal opening, or it can be found with a crypt hook. Slotted anosopes are less satisfactory and in some instances of anal stenosis or painful anal lesions, inspection must be deferred until anesthesia is available.

Palpation is often of great value. If the index finger be inserted into the rectum and the adjacent structures palpated between the thumb and finger tip, a cord-like tract can often be felt extending from

the external opening to the base of a crypt. If this is not possible, the palpation of the cryptic area alone, will often reveal a small hard area indicating which crypt is affected. In other instances a rather bulky area of induration is felt adjacent to the anus. This often indicates the general direction of the tract and is suggestive of accessory sinuses being present.

The fistula is now examined with a fine probe. An ordinary malleable probe is usually useless because of its diameter. We have found the Early probe, which has both a straight and a curved end and is made of fine-gauge stiff wire, most satisfactory for this purpose. In many instances of simple fistula, the probe can be passed entirely through the tract and into the bowel. Regardless of the method of examination, it may be found at operation that a seemingly simple fistula will have one or more accessory branches which are far more extensive than the tract which was discovered at the time of examination. Beginning an operation for fistula with too definitely preconceived ideas as to extent, is likely to result in some accessory sinuses being overlooked. One reason we object to the use of bismuth and dyes is that they may give the surgeon a false sense of security as to his knowledge of the extent of the lesion.

The cure of a fistula is based upon a very few fundamental "musts." The internal opening must be found. An incision must be made from the external to the internal opening. All accessory sinuses must be found and either incised and curetted or dissected out. At the completion of the operation, a broad, clean, flat wound without overhanging edges must be created.

The first step in the operation is to locate, if possible, the internal opening. Under anesthesia this is often possible, where before the attempt has been unsuccessful. The anus and lower rectum are dilated and the crypts examined as previously described. If the opening is not found, the operator should attempt to manipulate the probe carefully through the

tract by inserting the tip into the external opening and gently working toward the bowel. In many instances in which the tract is tortuous, it will be impossible to pass the probe through the entire tract to the primary opening. In this case it is best to insert the probe as far as possible without undue force and then incise the sinus as far as the probe has been inserted. Here the tract will often be found to have made a turn at an angle so acute as to have prevented further passage of the probe. However, with the distal portion of the tract incised, the probe can now be further advanced along the sinus. Proceeding in this manner, each time incising that portion of the sinus through which the probe has been advanced, the operator arrives at the internal opening of the fistula. It is well to follow the tract carefully and to disturb it as little as possible until the internal opening is located. The removal of lateral tracts or a portion of the main tract before the primary opening is found, often renders its discovery much more difficult. In cases in which the internal opening is difficult to locate, a maneuver of Newton Smith is often of value. After the fistulous tract has been partially freed, tension is made on the scar tissue, carefully watching the cryptic area. In many cases the traction will cause a dimpling in the base of the crypt where the fistula originates. In the rare instances in which the internal opening has healed over the surgeon can still be sure of the site of origin.

After the primary sinus has been incised, all secondary branches must be located and either incised or excised. As the first step toward this end, the granulation tissue lining the primary sinus should be carefully and thoroughly curetted away so the smooth and glistening scar tissue forming the tract is plainly visible. When this has been done, the openings to the accessory sinuses can usually be recognized by small tufts of granulation tissue extruding into the parent sinus. Curetting of the main sinuses will not remove these tufts and they stand out in distinct contrast to the

smooth fibrous tissue walls of the primary sinus. A probe is now inserted into one of these accessory sinuses and the tract incised. After it has been incised to its termination, it is curetted or removed as is thought best. Proceeding in this manner all accessory tracts are dealt with in a similar way. All tissues in the suspected area are carefully palpated between the thumb and index finger for any indurated areas. This may reveal a further accessory sinus which has been previously overlooked. It is very easy to miss accessory sinuses and it is important not to be hurried, but to be careful and deliberate in searching for them. As has been said, no one can be certain before the operation, just how extensive a fistula may be. Lack of recognition of this fact, coupled with being too hurried, is a material factor in the frequent unsuccessful operation for fistula. Contrary to some, we do not believe it advisable to dissect out all of the fistulous tract. In no event should that portion of the tract containing the internal opening be removed. To do so causes a greater gaping of the terminal opening of the rectum, a greater subsequent deformity and a greater loss of sphincteric function. This portion of the tract should never be treated other than by simple incision. Probably the second most frequent cause of failure, is the failure to be radical enough in the operative procedure. At the completion of all fistula operations the site should present a broad flat, clean wound with no overhanging edges. To accomplish this the skin margins should be trimmed back widely and the underlying fat removed. All ragged tissue in the wound, resulting from the incision of the fistulous tracts should be excised. This type of wound will heal readily and completely, and after-care is simple and painless. Where a deep narrow wound is left it must be packed daily and the dressing is painful. Bridging of the wound is more likely to occur, and in any event the packing will produce a greater amount of scar and subsequent deformity. A broad, flat wound simply requires daily cleansing which is

painless and no packing is necessary. Occasionally, at the completion of the operation a small gauze wick is placed in the wound, but once this is removed it is not replaced.

than those, in which external appearances may not indicate so extensive a lesion. The long superficial tracts should be incised down to the original sinus. Only a single

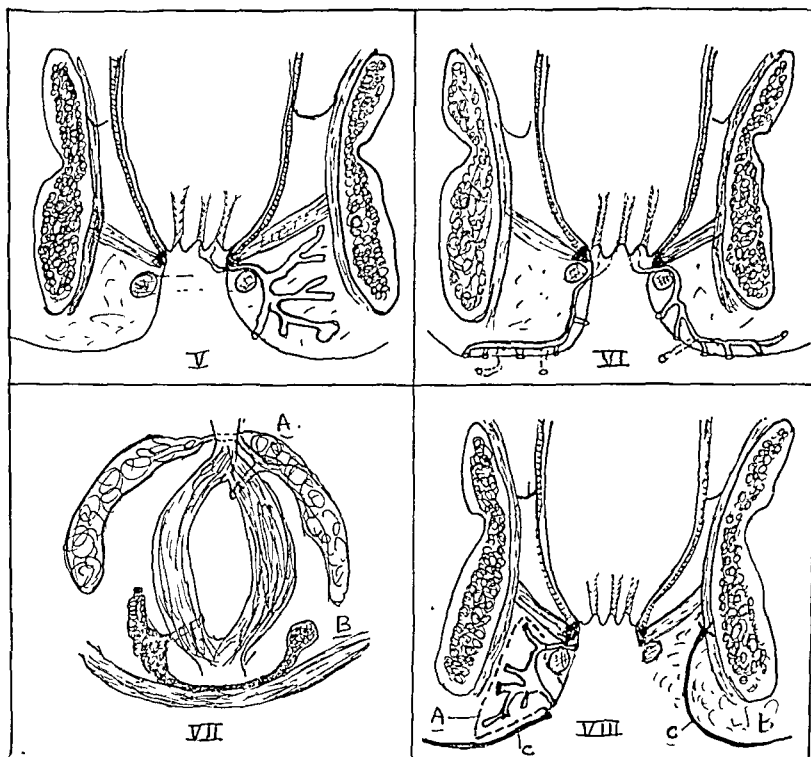


FIG. 2. v, deeply seated fistula with multiple sinus involving one entire fossa; usually one (or more) external openings rather near anus. vi, superficial fistula with many external openings far from the anus; deeper portion of ischio-rectal fossa not involved. vii, posterior and anterior horseshoe fistulas indicating most frequent method of spread: (A) posterior—behind the anococcygeal tendon; (B) anterior—along the sheath of the transversus perinei muscle. viii, diagram of operation for deeply seated fistula shown in v: (A) block of tissue to be removed outlined—and skin to be saved (C); (B) skin flap (C) sutured in place to cover defect partially; external sphincter divided.

Anal fistulas which have more than a single tract, usually result from failure to drain the abscess early. These fistulas may be classified in three general groups: First, fistulas in which the secondary tracts are superficial. (Fig. 2, Part vi.) In these fistulas, the accessory tracts are caused by the infectious process burrowing in the superficial fat adjacent to the anus and over the buttocks. These fistulas may have numerous openings at great distances from the anus. Because of the length of the tracts, they present a rather serious appearance but the fact that the tracts are superficial, renders their treatment more simple

sinus usually connects with the rectum. When this is incised through to the internal opening, healing usually occurs promptly and with no more deformity or loss of function than occurs in the case of a simple fistula consisting of a single tract.

In the second group, the secondary tracts are located in one ischio-rectal fossa but are deeply placed and the fossa may be honeycombed with these accessory sinuses. (Fig. 2, Part v.) There is usually but a single external opening, and until the operation is under way the surgeon may believe himself to be dealing with a simple fistula consisting of a single tract. In these

cases it is often necessary to dissect out the entire contents of the ischiorectal fossa. This leaves a deep cavity with its apex above the internal sphincteric ring. A wide area of skin and fat of the ischiorectal fossa should be removed, leaving a cone-like wound with the base external. This type of wound will heal readily without bridging. A wound left by a less radical operation is almost certain to bridge over and require subsequent operation. In very extensive cases a skin flap may be left to cover the defect partially. (Fig. 2, Part VIII.)

The third type of fistula is the so-called horseshoe fistula, the fistulous tract extending around the anal canal either anteriorly or posteriorly in the shape of a horseshoe. (Fig. 2, Part VII.) This condition results from an abscess which originates in one fossa and then extends to the other. This condition more than any other offers the most conclusive proof of the advantage of early drainage of perianal abscesses, as opposed to the method of procrastination and "expectant" treatment. If one has had the opportunity to watch the formation of one of these fistulas, the sequence of events cannot be misconstrued by the most casual observer. There is first an abscess in one ischiorectal fossa, and it is only after the abscess has been present for some time and the pus is under tension, that it will be seen to spread into the adjacent fossa. Early incision would of course have prevented this.

In the case of a posterior horseshoe fistula the spread is usually through the space just posterior to the anococcygeal tendon. Incision of the tract should be made from end to end of the horseshoe. The anococcygeal tendon is best divided. This will cause an anterior and upward retraction of the anus which causes some deformity, but does not cause any impairment of function. In most cases the primary opening will be found in the midline posteriorly. We usually do this operation in two stages, since we believe this method causes less

residual deformity. After the tract is incised and the margins trimmed back, a seton is passed through the internal opening and tied posteriorly. This bridge of tissue is divided after the remainder of the tract is contracted and partially healed. An anterior horseshoe fistula occurs less frequently and is more often seen in women. The arms of the horseshoe are not likely to be as long as in the posterior type. Again we prefer to do this operation in two stages. In the female there is likely to be considerable deformity and some difficulty in accessory bowel control. It has been definitely noted that division of the external sphincter anteriorly causes a wider gaping, a greater impairment of function than division elsewhere.

Operation for simple fistulas consisting of a single tract is minor surgery, but operation upon complicated fistulas is distinctly major surgery. Failure to recognize this fact is the chief cause for the repeated operative procedures and miserable results in many of these cases. There is no rule of thumb by which these patients can be operated upon, and that is the rub for the average surgeon. Every complicated fistula must be viewed as a new problem which is likely to present certain conditions not encountered before. All cases should be approached with some diffidence. A thorough knowledge of the anatomy of the region is essential. More important is a knowledge of what occurs in the way of deformity and impairment of function when the various muscles, tendons, nerves and other tissues of this region are cut, injured or removed. These last facts I am afraid are not too common knowledge, and without this knowledge complicated fistulas cannot be cared for to the best advantage.

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# ANAL, PERIANAL, PERINEAL AND SACROCOCCYGEAL SINUSES\*

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THE term "sinus," in a pathologic sense, pertains to a tract or tube, inflammatory in origin, blind at one end and communicating at the other with a cutaneous or mucosal surface.

"Fistula" is the Latin word for "pipe" or "reed," and pertains to a tract or tube, inflammatory in origin, and open at both ends. Both openings may lie upon the internal surfaces of hollow viscera, or one may lie internally and the other may involve an external surface of the body. Hence a fistula can be described as an abnormal communication between two hollow organs (e.g., rectovesical fistula) or as a communication between a hollow viscus and a body surface (e.g., fecal fistula).

Accordingly, therefore, the terms sinus and fistula are not synonymous. Failure to make this distinction is responsible for considerable confusion relative to pathologic processes in which fistulas and sinuses are formed.

Perhaps the safest plan in view of the subjects at hand is to consider all openings in the anal and perianal skin, the skin of the perineum and the skin of the sacro-coccygeal region, from which there is any kind of discharge, as draining "sinuses." Steps must then be taken to prove that a given draining sinus is actually a sinus or that it is one opening of a true fistula according to the premises stated above.

N. D. Smith<sup>19</sup> has provided a most practical classification which, in the essayist's humble opinion, serves admirably to indicate the ramifications of the problem of sinuses in the region of the anal outlet:

"Group I. Spontaneous inflammatory processes:

1. Fistula-in-ano
2. Incomplete fistula
3. Sinus or fistula associated with an anal fissure
4. Rectovaginal fistula
5. Infection of lymphatic vessels
6. Periurethral abscess

"Group II. Lesions arising in glandular structures or cysts:

1. Pilonidal cysts
2. Chromaffin bodies
3. Multilocular cysts
4. Bartholin cyst abscesses
5. Pyodermia (hidradenitis suppurativa)
6. Dermoid cysts

"Group III. Lesions due to unusual etiology or direct trauma:

1. Tuberculosis
2. Actinomycosis
3. Osteomyelitis
4. Penetrating injuries
5. Lymphogranuloma inguinale
6. Malignant lesions such as carcinoma, epithelioma and lymphosarcoma

"Group IV. Pseudosinuses:

1. Congenital anal dimples
2. Post-anal dimple
3. Comedones
4. Marked enlargement of hair follicles."

The author will attempt to consider first those sinuses occurring in the anal, perianal and perineal regions, and lastly, sacro-coccygeal sinuses. It is acknowledged that a pilonidal sinus may present at a point lateral to the anus and even anterior to it,

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but for practical purposes this plan should serve adequately.

#### ANAL, PERIANAL AND PERINEAL SINUSES

Inasmuch as the majority of so-called draining sinuses in the anal, perianal and perineal regions actually represent the secondary openings of anal fistulas, a consideration of the pathogenesis of anal fistula is indicated at once. Confusion with regard to this subject is inevitable in view of the teachings that an anal or ischiorectal abscess must be incised promptly or else a fistula will result, that an abscess is the first step in the formation of a fistula, and that most anal fistulas are tuberculous in origin.

It is not uncommon to find, in most textbooks of anorectal disease, that abscesses are discussed in one chapter and fistulas in another. The student is thus led to believe that the two processes have very little, if any, relationship to each other. An attempt will be made in the next few paragraphs to show, according to the teaching of Buie,<sup>5</sup> that abscess formation is merely one stage in the development of an anal fistula. A thorough understanding of these processes is essential to proper diagnosis and to adequate therapy and will serve to dispel unwarranted confusion relative to the subject.

Figure 1, part 1, is a diagrammatic representation of a longitudinal section through the anal wall, the wall of the distal portion of the rectum and the anorectal junction. At the bottom of the anal crypt there is usually a well marked transition from rectal mucous membrane to anal skin. Also in or near its base the anal crypt communicates with one or more anal ducts which lead to vestigial anal glands. The nervous physiology of the anorectum is such that the skin of the anal canal (including the structures of the dentate margin) and the perianal skin are supplied by somatic sensory nerves. The rectal mucosa harbors, if any at all, only visceral sensory fibers. It follows, therefore, that

rectal lesions, except those which lie close to the dentate margin, do not give rise to pain early in their course. Anal and perianal lesions on the contrary are commonly featured by varying degrees of pain or discomfort.

The story of the anal ducts and anal glands is interesting in view of the attention which has been accorded them again in recent years. Herrmann and Desfosses<sup>10</sup> described these structures in 1880 and said (author's translation): "From a surgical standpoint these long tortuous ducts, marked at their extremities by small follicles, present a certain interest particularly with regard to the role which they can play in the production of complicated fistulas which one encounters so frequently in this region."

In 1914, F. P. Johnson<sup>11</sup> published his splendid work on the development of the rectum in the human embryo including the embryology of the anal glands. He called attention to the work of Herrmann.

Pennington,<sup>16</sup> in 1917, wrote: "That an important anatomic fact could in this scientific age, be disregarded or lost sight of for many years, after being placed on record, and then, without knowledge of its former discovery, be rediscovered and found to be of great importance as a disease producing factor, is almost unbelievable. However, this anatomic finding, when resurrected, proves to be a vital etiologic factor in the causation of fistula and other diseases of the rectum, with their metastatic sequelae."

In 1933, Tucker and Hellwig<sup>27</sup> presented their work on the histopathology of the anal crypts, including an excellent comparative anatomic study, before the American Proctologic Society. Pope and Gunn, in discussing this paper, presented their own work which confirmed the findings of Tucker and Hellwig. These authors made no mention of the writings of Herrmann or of F. P. Johnson.

It is thought that infectious material from the stools, with or without trauma, frequently collects or is caught in an anal



crypt. The associated anal ducts easily afford portals through which infection can gain entry into the perianal tissues. (Fig.

The fourth and final stage in the development of an anal fistula pertains either to spontaneous rupture of an anal abscess or

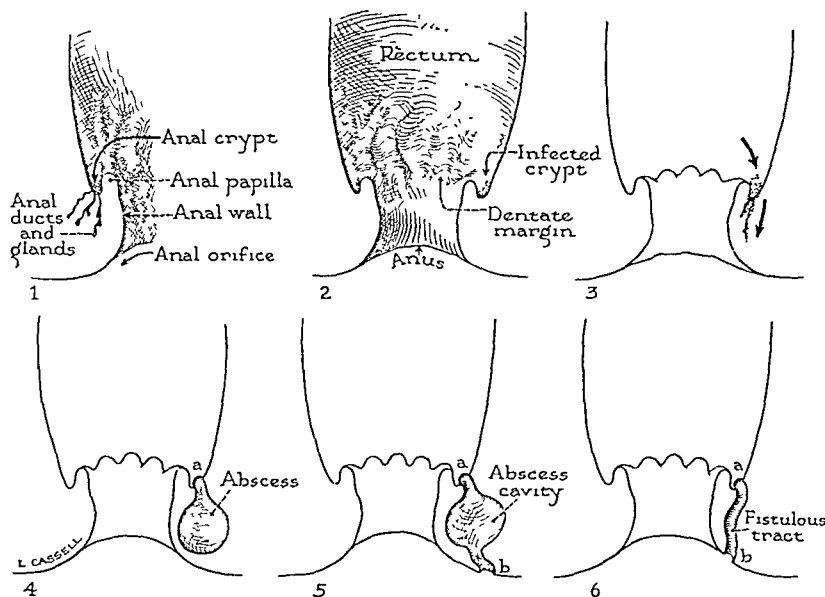


FIG. 1. 1, coronal section illustrating anal crypt, and anal ducts and glands. 2, coronal section; first stage of formation of anal fistula. 3, coronal section; second stage of formation of anal fistula. 4, coronal section; third stage of formation of anal fistula. 5, coronal section; fourth stage showing completion of fistula: (a) primary opening; (b) secondary opening. 6, coronal section; chronic anal fistula: (a) primary opening; (b) secondary opening.

1, parts 2 and 3.) The involved crypt thus becomes the "primary" opening of the fistulous tract which as yet has not been completed.

Then follows the second step—that of invasion of the soft tissues via the lymphatics and blood vessels, the lymphatics probably playing the more important rôle. (Fig. 1, part 3.)

Once infectious material has invaded the soft tissues of the ischioanal fossa the stage is set for abscess formation. (Fig. 1, part 4.) It is during this third stage, and not before, that the patient usually presents himself to his doctor with all the signs and symptoms of acute inflammation: redness, swelling, local heat, tenderness and pain. A practical point is well worth considering here. An anal abscess (frequently called ischiorectal or ischioanal abscess) should be incised as near the anal margin as possible without disregarding the point of fluctuation if present. Thus the doctor may be able to establish a shorter fistulous tract.

to incision and drainage of the abscess. Either occurrence provides the other or "secondary" opening, thus completing the fistula according to the definition set forth above. (Fig. 1, part 5.) The patient is much relieved when his abscess is drained, and the abscess cavity rapidly contracts to a narrow tube. (Fig. 1, part 6.) Thus it can be said that an anal fistula is, in effect, a chronic anal abscess. It is well, however, for the doctor to explain to his patient that the relief which he has obtained following drainage of the abscess does not mean that his trouble has been cured. A cure cannot be accomplished without the performance of a "fistula operation." The author always attempts to explain the problem to his patient by means of simple diagrams similar to those shown in Figure 1.

The terms "primary" and "secondary" have been suggested by Buie<sup>6</sup> for the openings of an anal fistula in order to correct the confusing terminology which has heretofore been applied to these openings. The point

of origin of an anal fistula, which has been shown to be an anal crypt, is commonly known as the "internal" opening. The terminal point is designated as the "external" opening. These terms are entirely proper for an anal fistula which ends in anal, perianal or perineal skin. When, however, the terminal opening lies in the rectal wall above the dentate margin, or in the vagina, etc., that opening, too, becomes "internal," and confusion is inevitable. If the involved anal crypt be known as the "primary" opening, then any and all other openings associated with this same fistula can be termed "secondary." The author heartily endorses this suggested terminology and finds that his students more readily grasp the relationship between pathogenesis and terminology with regard to the subject of anal fistula.

With regard to the pathogenesis of anal fistula some further elaboration must be considered relative to the "surgical spaces" about the anorectum. We shall then be prepared to take up the important subject of diagnosis—the theme of this symposium.

A surgical space actually exists only when the tissues normally present there are destroyed or displaced by the products of inflammation, i.e., abscess formation. These spaces can be created for demonstration in the cadaver by means of dissection. They are five in number.

Reference to Figure 2, part 1 calls our attention to two ischioanal spaces below the levators and to two pelvirectal spaces above the levators. There is a third space above the levators known as the retrorectal space which is best shown in sagittal and cross sections. However, for the purposes of this paper we shall consider only the two infralevator spaces known more commonly as the ischioanal spaces or fossae. The author prefers the term "ischioanal" suggested by Batson<sup>2</sup> in view of the fact that the levator ani muscle with its investing fasciae (pelvic diaphragm) passes between the internal and external sphincter muscles to gain attachment to the wall of the anal canal. Thus this space is more closely

related on its medial side to the anal canal than to the rectum, hence Batson's term "ischioanal."

The ischioanal fossa is involved, usually superficially but sometimes deeply, in the third and fourth stages of the development of an anal fistula. When a more complicated fistula, such as the "horseshoe" type, is present both ischioanal spaces are involved.

For all practical purposes the diagnosis of anal fistula depends on a history plus the findings afforded by two well known procedures in physical diagnosis—inspection and palpation. The facts thus obtained, and evaluated in the light of the pathogenesis of anal fistula set forth above, should enable the careful physician to arrive at a proper diagnosis.

The patient can usually remember the first abscess, and whether it ruptured spontaneously or had to be "lanced." Even if he fails to remember the abscess he will report the characteristic periodic drainage from a "point near the rectum" (meaning anus, of course). The patient may report having had several abscesses. This most likely has been a recurrence, at irregular intervals, of the same trouble. As long as a fairly constant drainage occurs there will be no recurrence of the abscess. When, however, the secondary opening becomes "healed over" there may result a backing up of secretions and exudate with reappearance of the signs and symptoms of acute inflammation. Unless the doctor understands the nature of an anal fistula he may think that he is dealing with a new abscess each time. As noted previously the author endeavors to explain to his patient, as simply as possible, that drainage of the abscess merely affords relief from the acute symptoms, and that more radical surgery (fistulectomy) is essential to a cure.

With regard to inspection let us consider first external inspection, and later on, internal inspection or endoscopic examination.

The examiner closely scrutinizes the skin of the buttocks, lower back and perineum. Then, upon gently retracting the buttocks, he can see the medial aspects of the but-

tocks and the anal and perianal skin. A draining sinus (to be considered the secondary opening of an anal fistula until

of long standing there may be considerable scar tissue present. The opening may even appear to be "healed over." There may be

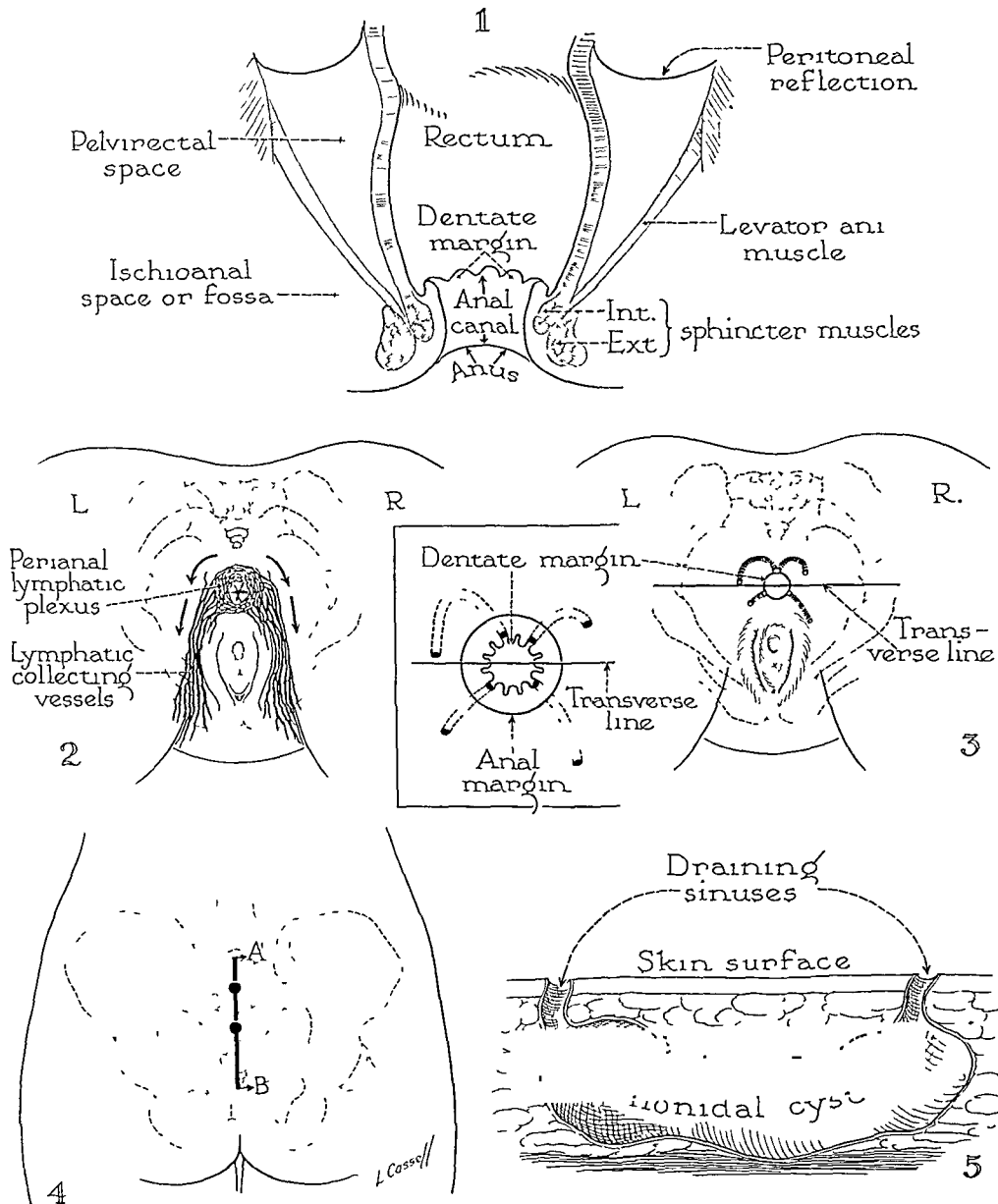


FIG. 1. Coronal section illustrating the surgical spaces about the anorectum (except the retrorectal space). 2, anal and perianal lymphatics in the female. 3 and inset, illustrating Goodsall's rule. Modified from Gabriel. 4, posterior view showing sacrococcygeal region. The line, A-B, represents the usual sites of pilonidal sinus openings in the skin of this region. 5, longitudinal section along the line A-B of 4.

proved otherwise) may present as a small elevated opening with some discoloration of the surrounding skin. Granulation tissue is likely to border on the edges of the opening. In the instance of a secondary opening

one or several draining sinuses. The approximate location of each opening and its distance from the anal margin should be noted. The amount of discharge from a draining sinus varies greatly. When there

has been copious discharge over a considerable period of time, the patient is likely to have resorted to the constant use of some kind of dressing.

Gentle palpation of the tissues about the draining orifice may disclose a firm, subcutaneous "cord" leading from the opening toward the wall of the anal canal. This represents the fistulous tract itself connecting the primary and secondary openings. (Fig. 1, part 6.) Whether or not a tract can be felt on superficial palpation the examiner should next proceed to a careful "bidigital" examination of the anal and perianal tissues. This is done by inserting the examining finger (index) within the anal canal and lower rectum. One can then palpate the tissues in question between the index finger and the thumb of the same hand. Such an examination frequently yields information that would have been overlooked ordinarily. This procedure is especially valuable at the time of surgery when complete relaxation of the anal outlet has been established by means of regional anesthesia. Under these circumstances the author frequently discovers a fistulous process of which he was unaware at the time of the first examination of the patient.

In view of the stages of development of an anal fistula as outlined previously it is readily apparent that the doctor must carefully examine the structures comprising the dentate margin and forming the superior boundary of the anal canal, the inferior boundary being the anal margin or anal verge. Careful palpation may enable the examining finger to follow the cord or tract directly to the primary opening in an anal crypt. If the examiner cannot identify a tract, he may be able to feel induration or scarring in the region of the involved anal crypt. Here, again, bidigital examination is an invaluable procedure. The examiner may find an area of induration above the dentate margin beneath the rectal mucosa leading to a "puckered" area in the mucosa. This is most likely an "internal" limb of an anal fistula, the secondary opening of which lies in the mucous mem-

brane of the rectum. This type of fistula is not, however, within the scope of this paper.

Following external inspection, and palpation of the anal and perianal tissues, the doctor next proceeds to internal inspection or endoscopic examination by means of an anoscope or a proctoscope. This procedure should serve to confirm or to disprove the impressions which the examiner has obtained on palpation. The principal goal here is direct inspection of the dentate margin. Not infrequently the involved crypt can be identified by means of a drop or two of pus seen oozing from it. Again the scarring in the region of the involved crypt may have caused sufficient deformity to be recognized on direct inspection. Finally, it may be that direct inspection of the dentate margin will yield no evidence whatsoever of a primary opening. The examining finger may have disclosed more information than the anoscope.

At this point the reader's attention is called to the fact that no mention has been made thus far of the use of probes or of the use of dyes in attempting to determine the course of a fistulous tract.

The author is heartily in accord with the teaching of Buie and N. D. Smith relative to the use of probes. Nearly every new patient who consults the proctologist is in fear of the examination because of unsavory stories which he has heard about proctoscopy or because of a previous unfortunate experience in the hands of another doctor. Since there is absolutely nothing to be gained by causing a patient to suffer excruciating pain at the time of his examination, and in view of the fact that sinuses and fistulous tracts can be explored by the use of probes with considerably more satisfaction when proper anesthesia has been established, it seems only logical to defer "probing" until the time of surgery. The author does not hesitate to suggest to a patient who has an extremely painful condition that he submit to an examination under regional anesthesia in the operating room where the investigation can be done without causing pain and

where surgical treatment can be carried out as indicated at the time. The suffering patient is usually quite willing and the advantages of such an arrangement to the doctor are obvious.

Although the details of the surgical treatment of anal fistula are not within the scope of this essay, a point of practical importance relative to the use of probes at the time of surgery seems in order at this point. With the anal canal adequately dilated a soft, silver probe should be bent at a fairly sharp angle and gently introduced into the suspected anal crypt. If the tip of the probe can be recovered at the secondary opening of the fistula, the tract has been explored from its primary opening or point of origin to its secondary opening or point of termination. This procedure helps to "drive home" our conception of the development of an anal fistula. When, however, one fails to pass the probe in the manner just described, he can then straighten the probe and attempt to explore the tract from its secondary opening, thus hoping to recover the tip of the probe at the primary source of the fistula. Even this method may fail, usually because of a sharp angulation in the course of the tract. Should this occur the surgeon can pass one probe through the secondary opening and another probe through the suspected primary opening, and he can usually determine by feel when the tips of the probes come into contact.

It is hoped that the description of the pathogenesis of an anal fistula which has been given in the foregoing pages will serve to indicate to the doctor that dyes, colored solutions, etc., are not essential to the discovery of a primary opening. He should know that the point of origin of the fistula is to be found in the dentate margin. Nor is the staining of a fistulous tract by some kind of dye (e.g., methylene blue) necessary for its identification. The characteristic appearance of the wall of the tract, when laid open, is discernible grossly. The author's preceptor, the late Collier F. Martin, was of the opinion that the surgeon who used a dye in attempting to demon-

strate an anal fistula was usually successful only in demonstrating his lack of knowledge of the pathogenesis of this entity.<sup>12</sup>

In the occasional instances of a sinus resulting from an impalement injury or of a sinus which is osteomyelitic in origin the doctor is justified in the use of injections of lipiodol to facilitate roentgenologic study of the location and extent of the sinus. He should remember, however, that the injection mass may follow normal planes of cleavage and thus misrepresent the true state of affairs.

A question might be asked logically at this point regarding the location and pathways of anal fistulas. Do anal fistulas follow any definite pattern of arrangement with reference to the anal canal?

Some years ago Goodsall observed "that fistulae with an external opening situated behind an imaginary line passing transversely through the center of the anal opening, usually have the internal aperture in the midline and posteriorly, so the track is curved. On the contrary, where the external opening is anterior to the transverse line, the internal one, as a rule is immediately opposite, hence the track is straight."<sup>17</sup> This observation has come to be known as Goodsall's rule, and is represented diagrammatically in part 3 of Figure 2 which has been modified from Gabriel.<sup>9</sup>

As a possible means of explanation of Goodsall's rule let us examine briefly the lymphatic drainage of the anal, perianal and perineal tissues.

Figure 2, part 2, is modified from the author's thesis.<sup>14</sup> The lymphatics of the anal and perianal tissues in the newborn were filled with mercury using the "multiple puncture" method. It can be seen that all the collecting vessels, whether they arise posteriorly, laterally or anteriorly from the anal network of origin, eventually pass anterolaterally on their way to the regional inguinal nodes. This work confirms the observations of the classical authors in this field. Since the lymphatics play an important rôle in the spread of infections, it would seem logical to believe that an anal fistula arising in the dentate

margin posteriorly would tend to follow the course of the collecting lymphatic vessels which course, posteriorly and laterally, is curved. By the same reasoning a fistula arising in either of the two anterior quadrants would be likely to follow a fairly direct course to its secondary opening.

#### DIFFERENTIAL DIAGNOSIS

Under this heading let us consider the other, but less common, types of fistulas and sinuses which may involve the anal, perianal and perineal skin. Brief mention will be made of the essential features which might facilitate differentiation of these entities.

For didactic purposes let us consider these subjects first in outline form:

1. Anal fistula in association with anal fissure
2. Anal fistula of specific etiology:
  - (a) tuberculosis
  - (b) actinomycosis
  - (c) venereal lymphogranuloma
  - (d) malignancy
3. Rectovaginal fistula (anovaginal)
4. Anal fistula in acute dysenteries (e.g., chronic ulcerative colitis)
5. Anal fistula accompanying regional ileitis, etc. (Crohn)
6. True sinuses:
  - (a) true anal sinus, so-called incomplete fistula
  - (b) penetrating injuries—impalement, enema tips, etc.
  - (c) osteomyelitis of sacrum, coccyx or pelvic bones
  - (d) foreign body
  - (e) pyoderma, or hidradenitis suppurativa, etc.
7. Perineal sinuses:
  - (a) lymphatic abscess (Buie)
  - (b) urinary tract—periurethral abscess
  - (c) Bartholin cyst abscess

At the distal margin of a chronic posterior anal fissure one frequently finds a large skin tab known as a "sentinel" tag or pile. This tag is the result of inadequate drainage at the outer margin of the fissure. As infectious material continues to be caught

beneath the outer margin of the fissure, a tiny abscess may form beneath the skin. Spontaneous rupture provides a secondary opening immediately distal to the sentinel tag. Thus a true fistula is established—a short subcutaneous tract arising at the distal margin of the fissure and ending 1 or 2 cm. further distally. It is not, however, an anal fistula proper since it does not arise in the dentate margin. This lesion can be identified easily at the time of surgery.

In tuberculous anal fistula the *Mycobacterium tuberculosis* is usually a secondary invader. Buie, N. D. Smith and Jackman<sup>7</sup> believe that the diagnosis is best made by means of properly done inoculations of guinea pigs. On the other hand C. L. Martin and Sweany<sup>13</sup> state that positive guinea pig tests are of value only in patients who present negative sputa. These authors advocate histopathologic study as the only pathognomonic test.

Involvement of anorectal tissues by actinomycosis is rare. However, one should be able to find the typical "sulphur granules" in the purulent material from an actinomycotic lesion, and to demonstrate the ray fungus on microscopic examination.

Among the protean manifestations of venereal lymphogranuloma are anal fistulas, especially in the female in whom the genito-anorectal syndrome is more likely to be found. Attention has already been called to the probable rôle played by the lymphatics in the development of an anal fistula. Since the causative virus in venereal lymphogranuloma is usually spread via the lymphatics, one might expect anal fistulas to occur, especially where an inflammatory rectal stricture exists. Infectious material from the ulcerated and narrowed rectum could easily enter the perianal tissues through the anal crypts and anal ducts. Rectovaginal fistula occurs frequently in these patients together with elephantiasis (lymphedema) of the external genitalia. The specific intracutaneous test of Frei should be done using several different antigens if necessary.

Rosser<sup>18</sup> has called attention to the development of a malignant process in a

fistulous tract and believes that the fistula may act as an etiologic agent. N. D. Smith,<sup>20</sup> however, suggests that the fistula develops secondarily, and this has been the author's experience. Thorough examination, under regional anesthesia if necessary, together with microscopic study of tissue specimens should help to clarify the picture.

True rectovaginal fistula is a communicating pathway between the rectum and the vagina through any part of the rectovaginal septum, and is not within the scope of this paper. The more common form of rectovaginal fistula is, in reality, an "anovaginal" fistula inasmuch as the primary opening lies in an anterior anal crypt. The secondary opening is usually found in or near the posterior margin of the vaginal introitus. The identification of the lesion should not be difficult for the physician who fully understands the mechanism of development of an anal fistula. Careful bidigital palpation of the tissues is important. Probing, as stated previously, is more easily accomplished when regional anesthesia has been established.

Anal abscess and anal fistula are by no means uncommon complications in diarrheal disease such as chronic ulcerative colitis.<sup>24</sup> This is readily understandable when one considers the ease with which the liquid and highly infectious discharges can gain entrance to the anal crypts and anal ducts. The diagnostic problem is no different here than in the ordinary type of anal fistula. It is extremely important, however, that a complete proctoscopic examination be done in order that the presence of colonic disease be discovered. Patients harboring chronic ulcerative colitis do not tolerate surgery well, and anorectal wounds heal poorly if at all. The doctor is justified in establishing drainage for an anal abscess, but he should refrain from any deliberate anorectal surgery while there is the slightest evidence of active disease in the rectum and colon.

Penner and Crohn<sup>15</sup> in their study of regional ileitis have demonstrated fistulous processes which arise in the ileal area and

terminate in the perianal or in the perineal skin. The demonstration depends upon roentgenologic visualization of the tract after it has been filled with lipiodol. The authors admit that the proof of such a process is difficult, and state that anal fistula accompanying regional ileitis may be the ordinary type.

A true anal sinus as shown in Figure 1, part 4, can be said to exist when an anal abscess has formed but has not ruptured spontaneously or has not been incised. It is possible for the abscess to become partially drained through its primary opening with some relief to the patient. If sufficient drainage occurs in this manner, such a sinus becomes a chronic process subject, however, to acute flare-ups should the primary opening become occluded. Since the opening of the sinus lies in the dentate margin, it can be seen only on internal (endoscopic) inspection at which time a drop or two of pus may be seen oozing from the involved crypt. Careful palpation should afford the examiner valuable evidence. At the time of surgery a chronic anal sinus can easily be rendered a complete fistula and then treated accordingly.

In the instance of a penetrating injury the history is usually significant. When the penetrating object enters the perineal or perianal tissues, a draining sinus may result the extent of which can be determined only by the use of lipiodol and subsequent roentgenologic visualization.

In most enema tip injuries the damage involves the skin of the perineum, the anterior anal wall or the anterior wall of the lowest one-third of the rectum. We are concerned here with the injury resulting from false passage of a hard enema tip beneath the perineal skin. There results from this type of trauma a sinus beginning in or near the anterior anal margin and extending anteriorly beneath the skin of the perineum. With the establishment of proper anesthesia such a lesion can be readily explored by means of a blunt probe. The tract should be widely uncovered.

Bacon and Taylor<sup>1</sup> report two cases of osteomyelitis involving the sacrum and

coccyx and accompanied by sinus formation simulating anorectal fistula. These authors stress the importance of x-ray in the diagnosis. According to N. D. Smith:<sup>21</sup> "Osteomyelitis of the bones of the pelvis, of pyogenic or tuberculous origin, may also cause the formation of an abscess and a subsequent persistent sinus or sinuses in this region. Grossly, such sinuses may resemble closely a fistula-in-ano. Lack of a demonstrable primary opening at the dentate margin, a palpable extra-rectal inflammatory mass attached to the bony pelvis and roentgenographic demonstration of alteration of the normal bony structure of the involved portion of the pelvis will provide the diagnosis."

Numerous objects, such as chips of bone, surgical needles, etc., have been reported as etiologic factors in persistent perineal and perianal sinuses. The writer has seen a rubber drainage tube with an attached safety pin removed from the ischioanal fossa during the surgical exploration of a longstanding draining sinus. Usually there is a history of previous attempts at anorectal surgery.

Since apocrine sweat glands are found in the genital and perianal areas as well as in the axillary, mammary and inguinal regions one must consider hidradenitis suppurativa. This entity, according to Brunsting,<sup>3</sup> "is characterized by the formation of abscesses and sinuses in selected regions of the cutaneous surface in which the apocrine type of sweat glands are situated. The favorite sites of involvement are the axillary, mammary, inguinal, genital and perianal regions. The disease affects young adults, usually occurring in the second decade of life. The course is extremely chronic and frequent remissions and relapses occur. The essential histologic features include primary involvement of the apocrine sweat glands and dissemination of the disease throughout the subcutaneous tissue by means of the lymph channels."

In a consideration of the causes of perineal sinuses in the male one must not overlook disease and deformity of the urinary tract. In rare instances a persistent perineal

sinus may result from a prostatic abscess or from perineal prostatectomy.<sup>8</sup> Urethral stricture may become so marked as to cause urinary extravasation necessitating incision for drainage. Sinuses will persist until the urinary tract obstruction is relieved. Urethral instrumentation may result in periurethral abscess and subsequent fistulous communication between the urethra and the perineal skin. Abscess of Cowper's gland may be the underlying cause of a perineal sinus. Hypospadias must be considered as a possible explanation of a urinary fistula opening upon the perineum. A careful history and a thorough urologic investigation will serve to establish a proper diagnosis.

Buie<sup>4</sup> has called attention to draining sinuses involving the perineum, usually in males, which simulate anal fistulas. There is usually a history of multiple operations, and it is difficult to identify any one anal crypt as the probable source of the process. Buie has obtained satisfactory results in these patients by excision of all the anterior anal crypts, the excision including all the skin between the anus and the secondary openings in the perineum. He believes, therefore, that this process is the result of anal infection with invasion of the superficial perineal tissues by way of the lymphatics which drain the anterior wall of the anal canal. Tucker, in discussing Buie's paper,<sup>4</sup> called attention to the probable rôle of the anal ducts in anal infection.

Although a Bartholin cyst abscess may be mistaken for an anal abscess, it seldom leaves a persistent draining sinus following spontaneous rupture. A persistent sinus, therefore, is evidence in favor of a true anal fistula. Careful inspection and palpation of the tissues together with anoscopic examination usually afford the proper diagnosis.

#### SACROCOCCYGEAL SINUSES

Although several interesting theories have been brought forth in explanation of sinuses, cysts and tumors of the sacrococcygeal region most authors agree that the complex developmental anatomy of the region favors these abnormalities. Stone<sup>25</sup>



thinks that pilonidal cyst may be the homologue of the "preen gland" in birds.

Pilonidal cyst is the most common of the lesions in the sacrococcygeal region which are developmental in origin. The adjective "pilonidal" is derived from the Latin words "pilus" meaning hair and "nidus" meaning nest. The cyst communicates with the surface of the overlying skin by means of one or more sinuses (Fig. 2, parts 4 and 5) which lie usually in the midline anywhere along the line AB. Although openings may be found to either side of the midline, and lateral to or even anterior to the anus, these additional openings are usually the result of infection of the cyst cavity. The author believes that the term "pilonidal sinus" should pertain only to the sinus openings and tracts, and not to the cyst itself, but common usage would indicate that the terms "pilonidal cyst" and "pilonidal sinus" are considered to be synonymous.

The usual patient harboring a pilonidal cyst is a young man of the "hairy" type in his late teens or early twenties who complains of a painful swelling at the base of his spine. There may or may not be a history of injury. The patient may be suffering from the "abscess" for the first time, or he may report that he has had several abscesses in this region, each one accompanied by painful swelling and followed by relief after spontaneous rupture or after incision for drainage.

Upon examination the physician finds the usual signs of an acute abscess involving the skin and subcutaneous tissues in the sacrococcygeal region. If he looks carefully, he may discover one or more small, round openings or "dimples" in the skin in the midline. There may be tufts of hairs protruding from these openings which can be easily withdrawn with forceps. The hair is usually quite long and is "silky" in appearance. The finding of such hairs is almost pathognomonic of a pilonidal cyst in which secondary infection has developed. Scars may be found indicating previous incision for drainage. The abscess should be widely incised.

Pilonidal dimples may be found acci-

dentally during the course of a routine examination. The examiner should be particularly alert when performing his external inspection of a patient of the hairy type. Knowledge of the presence of a pilonidal cyst is of value to the surgeon who uses sacral anesthesia in his anorectal surgery. The author feels justified in assuming that every pilonidal cyst is potentially infected and that, therefore, sacral anesthesia for some anorectal procedure is contraindicated.

It is believed that here again, as in the instance of sinuses or fistulas elsewhere, the use of probes should be postponed to the time of surgery when suitable anesthesia has been established. Careful probing enables the surgeon to outline the extent of the cyst, and he should attempt to carry his excision well into normal tissue. Dyes are unnecessary. The excised tissue is examined again with probes and should a probe easily pass through the base of the tissue, indicating a perforation of the wall of the cyst, the corresponding area in the base of the wound can be explored for gross evidence of "pilonidal" tissue. The pathologist usually does not like to have his specimen incised by the surgeon at the operating table, but there is no better method of teaching the surgeon the gross characteristics of "pilonidal" tissue, i.e., the greyish color and the gelatinous nature of the material within the cyst. These features together with the presence of hair in the cyst usually leave no doubt as to the diagnosis.

#### DIFFERENTIAL DIAGNOSIS

The secondary openings of anal fistulas may occur posteriorly in the sacrococcygeal region, and pilonidal sinuses may be found lateral to, and even anterior to, the anus. The diagnostic features of both entities have been indicated above.

Disease of the underlying sacrum and coccyx must be considered, and has already been discussed.

Needless to say the presence of any sizable presacral lesion should be disclosed by a careful digital examination of the

rectum. A retrorectal inflammatory process, anal in origin, must be considered.

Sinuses in the sacrococcygeal region due to chromaffin bodies, and sinuses due to dermoid cysts anterior to the sacrum are rare according to N. D. Smith.<sup>22</sup> Very little inflammatory change is found in the sinuses accompanying a chromaffin body, and the wall of the cyst (upon excision) is bright yellow in color. With regard to dermoid cysts Smith refers to roentgenologic study and to the discharge of sebaceous material from the sinus.

Another type of cyst lying anterior to the sacrum is the so-called "multilocular" cyst<sup>23</sup> with a sinus lying immediately posterior to the anus. The content of the cyst is a clear, gelatinous fluid and there is usually a history of several operations.

Thus far in his experience the author has not seen a presacral cyst or tumor.

Thomason<sup>26</sup> has divided the tumors and cysts of the sacrococcygeal region into those which lie dorsal to the sacrum and coccyx and those which are situated ventral to these bony structures. According to this author the pathological change in pilonidal cyst is simple, whereas ventral cysts and tumors are prone to undergo malignant change with spread by extension and invasion rather than by metastasis.

#### SUMMARY

In accordance with the accepted definitions of "sinus" and "fistula" an attempt has been made to indicate those lesions which are true fistulas and those which are true sinuses in the anal, perianal, perineal and sacrococcygeal regions.

Inasmuch as the great majority of so-called "draining sinuses" in the anal, perianal and perineal skin are in reality the secondary openings of true anal fistulas, an effort has been made to clarify the pathogenesis of anal fistula. It is hoped that a proper understanding of this mechanism will lead to more accurate diagnosis and to adequate management.

Pilonidal cyst is the most common "developmental" lesion dorsal to the sacrum and coccyx.

The essential differential diagnostic features of anal, perianal, perineal and sacrococcygeal sinuses have been briefly stated.

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# LYMPHOGRANULOMA VENEREUM\*

WITH SPECIAL REFERENCE TO RECTAL STRICTURE

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**D**URING the past decade and a half the pages of medical literature both here and abroad have been strewn with references to lymphogranuloma inguinale. The disease is of interest by virtue of the fact that we realize it is not new; that many cases of inguinal buboes have been and are manifestations of this disease; that inflammatory rectal stricture, which is encountered more commonly in women, is most frequently the result of a perirectal lymphangitis initiated by the specific virus of lymphopathia venerea; and that esthiomene, chronic elephantiasis or the combination of these, the genito-anorectal syndrome,<sup>1</sup> or the anorectal syphiloma,<sup>2,3</sup> are part of the same infection.<sup>4-8</sup>

Durand, Nicolas and Favre,<sup>9</sup> in 1913, offered the first detailed account of this disease although Heiner<sup>10</sup> reported eighteen cases in the same year. Referring to the pathologic process as "subacute lymphogranuloma inguinalis" they presented clinical and histologic data in an effort to prove that this disease was an independent entity. They held that it was contagious and of an infectious nature, which view is also stressed by Nealton.<sup>11</sup> In their description they mention that the disease is of genital origin, that the initial lesion is frequently unobserved but that the inguinal adenitis is a constant and prominent feature. Even though these workers did not appreciate the close analogy between this and climatic bubo, which since has been shown to be identical,<sup>12,13</sup> they did realize that this pathologic process was not a new disease.

Lymphogranuloma venereum or lymphopathia venerea is an infectious disease

usually of venereal origin caused by an unknown filtrable virus, characterized in the male by a somewhat insignificant initial lesion, which is followed by a suppurative inguinal adenitis, elephantiasis of the penis and scrotum and, less frequently, stricture of the rectum; in the female by stricture of the rectum, abscess, fistulas, anovulvar esthiomene and elephantiasis.

Many terms have been applied to this malady. The tortuous course this disease has taken in tracing its evolution through the history of medicine is indicated to some degree in the unusual names that have been applied to it in this country or another. They imply a lack of agreement among scientists owing perhaps mainly to the fact that they have been working more or less independently as to the nature, etiology, manifestations and significance of this condition. Those in general use are "lymphopathia inguinale" so called by Hellerstrom<sup>14</sup> and "lymphopathia venerea" as suggested by Wolf and Sulzberger.<sup>15</sup> Other names employed are lymphogranulomatosis inguinalis,<sup>16,17</sup> lymphogranulomatosis venereum,<sup>18</sup> subacute lymphogranuloma inguinalis,<sup>9</sup> simple subacute adenitis with purulent intraganglion, nontuberculous granulomatous lymphadenitis,<sup>19</sup> inguinal lymphadenitis,<sup>20</sup> hypertrophic bubo,<sup>21</sup> tropical bubo, strumous bubo,<sup>22-25</sup> climatic bubo,<sup>26,27</sup> malarial bubo, pestis ambulans, poradenolymphitis, poradenitis,<sup>28</sup> Nicolas-Favre's disease,<sup>29</sup> fourth venereal disease,<sup>30,31</sup> and sixth venereal disease.<sup>32</sup>

It was believed at first that the disease confined itself, or predominated in, the male; but observations, plus the obscurity

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of the primary lesion in the female as well as the suppression or deviation of pathologic manifestations, argue that lymphogranuloma venereum is, comparatively speaking, equally distributed between the sexes. To a great extent, the ratio is dependent upon the source of the series; for instance in our rectal clinics the preponderance is in the female although our colleagues in the genitourinary clinics observe a greater incidence in the male. Our series as reported in early 1941<sup>33</sup> was as follows: females, 567; males 285; total, 852.

The age incidence is usually from fifteen to forty-five or the period of greatest sexual activity. Isolated cases have been reported in children,<sup>52,107</sup> but in no such case was sexual irregularity or abnormality observed. In our series of cases, the greatest incidence occurred between seventeen and forty; three cases under the age of one were noted, the youngest of which was three weeks.<sup>34,35</sup>

#### INCIDENCE ACCORDING TO AGE

Below 1 year	9
14-29	301
30-39	368
40-49	98
50-59	51
60-69	17
70-79	5
80-89	3
Total	852

Early reports seemed to confine this affection to tropical races, notably negroes, but with the awakening of interest and observation in nordic countries some have come to believe that race plays no significant part in the incidence.<sup>36</sup> As shown by the accompanying table, the incidence in the colored race was much greater in the author's series and this seems to be the usual experience of investigators in this country.<sup>112,113,114</sup>

Colored	559
White	292
Chinese	1
	852

**Occupation.** Early observations practically confined this disease to sailors and

the lower classes inhabiting port cities; it was, therefore, believed to be carried from tropical regions on board vessels. Since, however, the study of this affection has been undertaken more or less universally, reports mention patients from nearly all walks of life. Gray and Yieh,<sup>37</sup> in a report from China, list students, housewives, hawkers, merchants, actors, soldiers, sailors, coolies, printers, blacksmiths, etc., with the highest number equally divided between coolies and housewives. In France, Flandin and Turiaf,<sup>38</sup> in a series of four, treated two clerks, a mechanic and a machinist. Hellerstrom noticed a predominance in ports; Stannus believes that the apparent high frequency in sailors is not a true occupational incidence while the lack of special comment on this phase by American observers would argue that the occupational incidence is so distributed as to justify no dogmatic conclusions as to any one class.

The mode of transmission is primarily and principally coitus. In this, experience justifies the inclusion of buccal coitus, and the practice of suction penis and cunnilingus. Scattered cases, moreover, evidence the possibility of extragenital infection as well as extragenital lesions.<sup>40-51,53,54,60,107-111,115</sup> In the rare cases of the children,<sup>52</sup> it was found that the mother had been infected and had used her wash cloth, enema tip, or other personal accoutrements on the child as well as having the child sleep in the same bed with her. Stannus<sup>55</sup> mentions two sisters, aged six and seven, respectively, who contracted the disease, manifested by inguinal masses the size of hens' eggs in one and ducks' eggs in the other, through the simple, ordinary contacts of living in the same house with an infected person. Physicians have become infected by surgical contact with these patients;<sup>22,56-58</sup> an instance has been cited in which the infection appeared first on the finger and later in the axillary glands.

The existence of two types of virus or of a double-acting nature in the single virus of lymphopathia venereum is a general

theory among those who are making a close study of this disease.<sup>59</sup> Although not yet identified, the virus is capable of passing a Berkefeld V and a Chamberland L3 candle. It will not pass an ultrafilter.<sup>6</sup> It has been found to survive at 2° to 3°c. below zero for ten days; at 4°c. for twenty-three days; at 10° to 20°c. for thirty days; at room temperature for twenty-four to forty-eight hours; at 46°c. for up to thirty minutes; at 56°c. for ten minutes; it is destroyed at 60°c. It loses its virulence in 0.1 per cent formol, in glycerin, and upon prolonged desiccation. Miyagawa and his associates<sup>62</sup> found it still active after thirty day's but inactive after thirty-five days' desiccation. Tamura<sup>63</sup> reports cultures made on Tyrode's medium, one being carried through twenty-four subcultures.

Lymphopathia venereum is freely and reciprocally inoculable among men and animals. The best experimental animals are mice, preferably white, guinea pigs, and monkeys, preferably the hepale penicillata or marmoset. Phylactos<sup>64</sup> has successfully inoculated rabbits in the cornea and believes that these animals promise to be equal or perhaps greater in value for experimental and diagnostic purposes than monkeys, which are costly and hard to obtain. Some strains become more virulent at each passage. Chatellier<sup>65</sup> has accomplished at least twelve passages of one virus; the Kamm strain, the most virulent, has been passed through twenty monkeys without attenuation. Conversely, the intradermal injection of a single strain into one patient becomes less potent at each injection. Microscopic study of inoculable material yields no distinctive characteristics. Rodlike bacteria, not unlike the Donovan bodies of granuloma inguinale, have been observed.<sup>48,66,67</sup>

Antigen prepared from animals is equally as valuable as human antigen. Lichtenstein and Von Haam<sup>68</sup> state that "brain emulsions of white mice and of monkeys (Hapale penicillata) infected with the virus of lymphopathia venereum provide a large supply of a uniformly potent antigen

for the diagnostic intracutaneous test. There is no danger of contamination with pathogenic organisms, particularly of the spore-bearing type, as there may be when pus from spontaneous buboes in humans is employed directly for the preparation of the antigen. Finally, the false positive reactions obtained occasionally with the Frei test are completely eliminated by this method." Nonfiltrated antigen is the more virulent. It is stated as a general fact that after two months the antigen is not reliable for diagnostic purposes, although scattered instances of reactions obtained with antigen older than this are recorded, Hellerstrom having used successfully an antigen over a year old.<sup>69</sup> It has been our experience that the Frei antigen is most active until about the third month and then diminishes in its potency until the ninth month after which it is usually inactive.

*Inflammatory Stricture of the Rectum.* Stricture of the rectum is an organic narrowing of the lumen of the bowel by fibrous tissue involving the mucous membrane, submucosa and muscular coat and characterized by progressive constipation, tenesmus and mucopurulent discharge. In 1931, the writer<sup>70</sup> noted the site in a series of 179 cases as follows:

	No. of Cases		Per Cent
Sigmoid.....	6	or	3.4
Within 5th inch above anorectal line.	8	or	4.5
Within 4th inch above anorectal line.	5	or	2.7
Within 3rd inch above anorectal line.	23	or	12.8
Within 2nd inch above anorectal line.	65	or	36.3
Within 1st inch above anorectal line..	49	or	27.4
Anal—at or below anorectal line (stenosis).....	23	or	12.9
	179		100.0

The incidence as to age, sex and race is as follows:

Age	No. of Cases
10-20.....	31
21-30.....	194
31-40.....	230
41-50.....	157
51-60.....	14
61-70.....	9
Over 70.....	4
Total.....	648

Sex	No. of Cases
Females.....	537 or 82.8%
Males.....	111
Total.....	648
Race	No. of Cases
Colored.....	447 or 68.9%
White.....	201
Total.....	648

Strictures of the rectum are classified according to their shape, as annular or tubular. The annular variety represents a ring-like constriction involving the entire circumference of the rectum; the tubular variety is so specified to denote a cannular or tube-like contraction of the entire circumference of the rectum.

*Pathology.* By way of the extensive lymphatic network and from initial lesions of the fourchette and vagina, invasion with the specific virus results in a nutritional interference in the regions draining into the adjacent glands. Lymphostasis is probably the result of the virus of lymphogranuloma venereum. It should be borne in mind that the inflammatory process may attack any layer of the rectum or the tissues outside its wall. If it is initiated from within, the irritation results in erosion of the mucous membrane upon which infection is superimposed. With continuation of the etiologic irritant the inflammatory process becomes subacute and finally chronic in nature, so that the various layers of the rectum and the tissues outside its wall are gradually involved by continuity and contiguity of structure. As a result of this chronic inflammation much young fibroblastic tissue is deposited in the submucosa as well as in the other coats, which gradually leads to thickening of the visceral wall. This in itself tends to encroach on the lumen of the rectum. By subsequent contraction of the maturing fibroblastic tissue, this thickening becomes markedly increased so that there eventually results a firm, inelastic, permanent narrowing to which the term stricture is applied.

On the other hand, if the initial focus is outside the rectum, as we believe is most

frequently the case, the extramural network of lymphatics becomes invaded. As the inflammatory process gradually becomes chronic the mural tributaries, namely, the inter- and intramural groups, are invaded by extension. As a result of the inflammatory process, fibrous tissue is deposited in the various layers of the rectum so that thickening occurs which brings about narrowing of its lumen. As the process continues and additional fibroblastic tissue is deposited, subsequent contraction ensues so that finally an organic stricture is formed.

At first, erosions of the mucous membrane are noted, followed by ulcerations, so that the surrounding mucosa appears altered and somewhat lusterless. To the touch, the involved area is thick and firm, while later it feels leathery, with loss of elasticity and distensibility. It is more or less irregular, markedly thickened, and the mucous membrane is found to be adherent to the tissue beneath. In the deeper layers of the stricture, fibrous tissue is seen involving all the coats of the rectum, although the greatest amount of involvement is in the submucosa. Fistulous tracts may be found passing to the perirectal tissues, to adjacent structures as the bladder, urethra, vagina or through the skin. Ulceration is usually marked and occurs early. The discharge is frequently abundant, mucopurulent and often sanious. Ulceration rarely exists at the level of the stricture except in the tubular variety, where we see it routinely through the stricturoscope and at autopsy. Above the stricture, the rectum is dilated and ballooned owing to the pressure of feces. In this location, ulceration is frequent because of irritation from the retained fecal contents and bacterial activity. Polypoid growths are not uncommon in this site. Below the stricture, the mucous membrane appears gray, it is tough and dense with loss of the normal velvety character. Here ulceration is less common. The mucosa and anal skin are often thrown into patchy thickenings and papillomatous vegetations

which may project into the lumen and through the anal orifice.

The histopathologic appearances of inflammatory rectal stricture are nearly always nonspecific regardless of etiology, save in the occasional case in which typical tuberculous granulation tissue is characteristic. In lymphogranulomatous strictures one finds small abscesses which are observed uniformly in the lymph-node. Ordinarily the following changes are noted: the ulcerated mucosa is replaced by simple granulation tissue; the entire wall of the rectum is more or less heavily infiltrated by a chronic inflammatory cellular exudate in which lymphocytes and plasmocytes predominate, monocytes and macrophages being in the background; a zone of neutrophilic leukocytes lies along the lumen margin and may, with eosinophils, be sprinkled sparsely throughout; fibroblastic proliferation is prominent in all coats of the bowel, later forming a dense, collagenous mat which may largely replace the original structures; blood vessels show the proliferative thickening common to any chronic inflammatory area and the environs of the lesion are usually surrounded by a round-cell collar.

Jones and Rome<sup>116</sup> investigated a series of seventy-three patients with lymphogranuloma venerea on whom a total of ninety-three protein determinations were made. Sixty-four per cent had total proteins greater than 8 Gm. per cent but more characteristically approximately 90 per cent showed globulin values greater than 3 Gm. per cent. In 32.5 per cent an albumin of less than 4 Gm. per cent was noted. Fifty-two per cent showed a reversal of the albumin-globulin ratio and this reversal was always due to an increase in the globulin fraction with or without a decrease in the albumin fraction. In the sixty-five determinations, whose values lay in the normal range between 6-9 Gm. per cent total protein, fifty-five showed an increase in the globulin fraction. This increase in globulin was due to an increase in the euglobulin portion of the globulin fraction.

Abnormally high globulin values have been noted in a few cases, in whom the globulin level fell to normal figures within one or two weeks and in one case there was a subsequent rise to a level higher than its previously noted hyperglobulinemic state.

The Takata-Ara reaction was positive in half of the cases without demonstrable evidence of a pathological condition in the liver. This reaction is likely to be positive in instances of hyperglobulinemia and offers a simple method for the detection of this alteration.

*Symptoms.* In all cases the symptoms vary with the degree of completeness of the constriction, and this is usually dependent upon its location and duration. Initially, a bearing-down sensation or a feeling of discomfort in the rectum frequently exists. Constipation is progressive and a constant desire for stool is cited by the patient so that futile and painful straining (tenesmus) soon ensues. The evacuations, which are always incomplete and which are increased by the use of various drastic purgatives, become liquid and tinged with blood so that, as the condition progresses there is an almost constant dribbling of mucus, pus and feces. Many writers stress the occurrence of ribbon-shaped stools in stricture of the rectum, but in our experience this is uncommon except in those instances in which the degree of constriction is marked and in which it is located immediately above the anorectal line. In anal stenosis, however, ribbon-shaped stools are of frequent occurrence. Soreness about the anus is frequently present owing to the excoriation caused by the irritating discharge. Concomitant gastrointestinal symptoms, as anorexia, meteorism, coated tongue, as well as loss of weight and general impairment in the health of the individual, are later manifestations. Not unimportant is the previous history, especially of anorectal and pelvic operations or disorders. In a series of 216 cases of which 173 were females, 143 or 82.6 per cent gave a history of previous pelvic inflammatory disease. A history of syphilis, either the initial

lesion or constitutional lues, was given in forty-two cases.<sup>71</sup>

*Diagnosis.* A history of constant soiling by feces, blood and pus is suggestive of an inflammatory stricture, especially when cited by a colored female between the ages of twenty and forty years.

*Inspection.* Although the diagnosis by inspection is not absolute, to the careful observer it offers more than a suspicion of the pathological condition present. Not infrequently the region about the anus is moist and glued together by the thick mucopurulent discharge. Upon separation of the buttocks, fecal matter mixed with blood and pus may be seen seeping through the anal orifice. Hypertrophied skin tags, condylomas of various sizes and one or more fistulous openings are not uncommon.

*Digital Examination.* Since approximately all inflammatory strictures of the rectum are within reach of the finger, the diagnosis is not difficult. As the gloved finger is inserted into the anal canal some degree of muscular relaxation is noted in longstanding cases, owing to fatigue of the external sphincter. As the finger is advanced the stricture is felt as a firm, inelastic narrowing, usually involving the entire circumference of the rectum. Through an ordinary proctoscope, the stricture (or in the case of the tubular variety, the lower border of the stricture) is noted by its pale, leathery and thickened appearance.<sup>72</sup> The introduction of the stricturoscope should be cautiously performed, preferably with the patient in the inverted position and with the instrument being advanced under direct vision. In this manner the type of stricture, whether annular or tubular, its length and its degree of ulceration may be determined.

In each case of stricture, especially when located high in the rectum or sigmoid, roentgenograms should be taken after an opaque enema. In this fashion, the irregular deformity will be noted. The method devised by Martin, Sturr and Bacon<sup>73,74</sup> has proved of distinct value in estimating the accurate length and site of rectal strictures.

A soft rubber catheter of small size, calibrated in centimeters by strips of lead foil, is encased in a rubber balloon and inserted into and through the stricture. The proximal end of the balloon is tied so that no barium will escape after its introduction through the catheter. Under the fluoroscope, the barium or other opaque solution is permitted to run in until the stricture is clearly outlined. Films are then taken and the length of the stricture as well as its distance from the anal margin can be readily calculated by means of the lead strips.

*The Frei Test.* One-tenth cc. of the antigen is injected intradermally into the arm of the patient. The reaction, which reaches its maximum from forty-eight to seventy-two hours after the injection, is then read. A positive test is characterized by the appearance of a hard red papule around which may be noted an erythematous ring. In some cases and especially when stronger dilutions are used (1 to 5), pustule formations occur as shown by a central area of necrosis.

*Control.* In order to evaluate the test properly, a control antigen obtained from normal glands of patients not affected with lymphopathia venerea should be employed. A sterile solution of leukocytes has been used also. Wang<sup>75</sup> suggests a control of phenol, 0.25 per cent, in normal saline solution. The material is diluted with physiologic salt solution as in the preparation of the specific antigen, after which 0.1 cc. is injected into the forearm of the patient. It has been our custom to inject the Frei antigen in the left forearm and the control in the right in order to avoid incorrect readings. When the control test is noted, which is at the time the Frei antigen is read, or forty-eight to seventy-two hours after injection, no elevation, pustule or erythematous zone should be present. Such constitutes a negative control test.

Male patients with this disease who present inguinal buboes will show a positive Frei reaction if tested one week



after onset of the adenitis, although the usual time is two weeks to two months. Cole<sup>76</sup> observed a positive test four days after appearance of the bubo and eighteen days after intercourse. In our series the earliest was twenty-one days after exposure.<sup>77</sup> Hellerstrom reports a case in which a positive reaction appeared four months after onset of the adenitis, having been negative during the second and third months. This investigator was able to prove that cutaneous manifestations were positive from eleven to twenty-four years after the appearance of the adenitis, and Cole observed a similar case at thirty years. In all probability the reaction, having once been proved positive, will remain so for life.

Antigens prepared from experimental animals (monkeys, guinea pigs, and mice) are equally as specific as the human antigen for diagnostic purposes and even for treatment. This fact, together with the ability to preserve antigen in concentrated form in dried pus, assures a sufficient and reliable quantity. In regard to preservation Grace<sup>90</sup> declares, "The titration of Frei antigens prepared from fresh and dried pus, respectively, has been carried out in eight normal and eleven lymphogranulomatous persons. The results obtained show a slight difference in titer in favor of the dried material."

The diagnostic value of the Frei test is now generally recognized, but its specificity, though practically 100 per cent, is still subject to doubt in some few cases. The author<sup>77</sup> in a previous article, tabulated the percentages of positive reactions as observed by various investigators, the majority showing 100 per cent and most of the remainder above 90 per cent. At the opposite extreme, a very recent article by Charles Flandin and Jude Turiaf, of the Hôpital Saint-Louis, Frances, states, "The opinion which we have reached is in accord with the conclusions announced by Ravaut in the thesis of his pupil, Maisler. The action of the lymphogranulomatous antigen is very inconstant."

Aside from microscopy of the tissue, the Frei test is, nevertheless, the most dependable factor in the diagnosis and the antigen is also valuable for treatment. It should be remembered that a negative result does not necessarily predicate freedom from contamination. The reaction may be negative in the initial phases of the disease, appearing later on when the infection has progressed from the lymph glands to the skin. In accompanying tuberculosis and syphilis the Frei reaction may be suppressed either partially or totally.

*Source of Material for Performing the Frei Test.* The material for the Frei antigen is obtained from patients with lymphopathia venereum as proved by a positive Frei test using a known positive antigen.<sup>77</sup> To prepare the antigen, either the pus or tissue may be used. Buboec that are unopened and present areas of fluctuation are preferable for obtaining purulent material. We have used successfully tissue from the anovulvar region of patients showing an esthiomenic process, fragments of rectal stricture, and pus from perirectal abscesses and fistulas occurring in cases with a positive Frei test.

*Preparation of Frei Antigen.* After the addition of physiologic salt solution as a diluent, the material collected is heated on a water bath at 60°C. for two hours one day, and at 60°C. for one hour the second day. Tests for sterility are performed on aerobic and anaerobic culture media and, if found sterile, the material is sealed in a sterile ampule ready for use. The antigen is then tested on known positive cases of lymphopathia venereum as previously determined by the obtaining of Frei reactions.

Ottolino<sup>104</sup> has devised an intracutaneous test using the cerebrospinal fluid of Frei-negative men. The fluid and the vacuum concentration is performed under aseptic conditions. By means of a graduated pipette, closed at one end and submerged at the other in the fluid contained in a porcelain capsule, the degree of concentration is determined. By reducing 10 cc. of the fluid to 1.5 cc., it resembles a col-

loidal solution, is opalescent and foams on agitation. Otilino found that if this concentrated fluid is injected intradermally, a vesicle appears in twenty-four hours which he terms "vesicular test." The shape is described as ovoid, circular or triangular with rounded angles but there is definite trend toward the hemispheric form. It measures 4 mm. in length, 2 mm. in width and 1 mm. in height. The color is light or dark brown, sometimes dark gray. This investigator is of the opinion that the concentrated cerebrospinal fluid in Frei-positive patients, when injected intradermally, has a certain antigenic power that provokes a blister reaction. The study of the vesicular test in different groups of patients showed that the test was positive in patients with poradenic virus infection, previously diagnosed by Frei's test.

INCIDENCE OF POSITIVE FREI TEST IN INFLAMMATORY RECTAL STRICTURE

Author	City	No Inflammatory Rectal Strictures	Positive Frei Test—Per Cent
Curth <sup>78</sup>	New York	50	100
M. Hill <sup>79</sup>	Los Angeles	34	100
Dalton and Ricketts <sup>80</sup>	Indianapolis	15	100
Alley <sup>81</sup>	Lexington	20	100
Vander Veer <sup>82</sup>	Philadelphia	21	100
Grace <sup>83</sup>	New York	20	100
Cole, DeWolf, Van Cleve <sup>76</sup>	Cleveland	13	100
Lehman and Pipkin <sup>84</sup>	San Antonio	3	100
Streicher <sup>85</sup>	Chicago	11	100
Marino <sup>86</sup>	Brooklyn	4	100
Grossman <sup>87</sup>	Harrisburg	4	100
Hayden <sup>88</sup>	Boston	20	100
Howard and Strauss <sup>89</sup>	New Haven	5	100
Bloom <sup>43</sup>	New York	7	100
Coutts <sup>59</sup>	Chile	2	100
Wang and Shen <sup>75</sup>	Nanking	2	100
Templeton and Smith <sup>91</sup>	San Francisco	1	100
Rutney and Cole <sup>92</sup>	St. Louis	14	100
Lichtenstein <sup>93</sup>	New York	56	98
Martin and Bacon <sup>94</sup>	Philadelphia	145	96 7
Sulzberger <sup>95</sup>	New York	6	96 3
Rajam <sup>96</sup>	Madras	22	90 9
Bensaude and Lambling <sup>97</sup>	Paris	143	88
Lee and Staley <sup>98</sup>	Cincinnati	14	87
Stillman <sup>99</sup>	New York	6	83
Pennoyer <sup>100</sup>	New York	22	81
Corachan <sup>101</sup>	Madrid	3	75
Hayes and Burr <sup>102</sup>	Houston	106	60 4
Bacon (1939) <sup>33</sup>	Philadelphia	648	91 6

*Differential Diagnosis.* Ordinarily it is not difficult to diagnose a rectal stricture but to determine the cause or the process

which bears influence is not always an easy task. The presence of amebiasis may be diagnosed by isolation of the *Endamoeba histolytica*; bacillary dysentery, by the characteristic bacterium and positive agglutination test of the blood; tuberculosis, by histologic and bacteriologic studies; syphilis, by means of the blood Wassermann, Kahn and Kolmer tests, and dark field illumination; gonorrhea, by isolation of the gonococcus of Neisser.

It should be mentioned, however, that in a large majority of stricture cases observed, a triad exists, viz., syphilis, gonorrhea and lymphopathia venereum. Tuberculosis, amebiasis and even malignancy may complicate the picture also.

DIFFERENTIAL DIAGNOSIS

	Nonmalignant Stricture	Malignant Stricture
Age	17-40	40-60
Race	colored	white
Sex	female	male
Palpation	firm but not nodular, orifice of stricture feels like a circular ridge	hard, nodular, edges thickened, irregular, induration is marked, new growth, more prone to cause obstruction
Involvement	entire circumference involved uniformly	more on one side than the other, not uniform
Odor	fetid	fetid and characteristic
Ulceration	above and below stricture	begins in growth
Metastasis	not present	present
Course and progress	chronic and slow	more rapid
Glandular involvement	infrequent and less marked	always present, comparatively early
Loss of weight	gradual	pronounced and rapid, cachexia early
Laboratory		
Biopsy	suggestive of L V	positive for cancer
Gruskin test	negative	positive for cancer
Frei test	usually positive	negative

Not infrequently, the physician will be called upon to distinguish between an inflammatory and a malignant stricture. Usually a stricture caused by carcinomatous infiltration occurs in the white race between the ages of thirty-five and sixty. Here, the mass is hard and nodular and confined more to one side than the other; whereas the inflammatory stricture is firm and the entire circumference is involved

uniformly. In cancer, the mass grows rapidly and obstruction is frequent. Glandular involvement is noted and cachexia malignant type is usually fatal unless resection is performed early while the prognosis is good in lymphogranulomatous

## DIFFERENTIAL DIAGNOSIS

	Inflammatory Stricture	Hyperplastic Tuberculosis	Sarcoma	Syphilitic Gumma
Age	17-40	20-30	30-50	middle life
Race	colored	white and colored	white	white or colored
Sex	females	males	males	females
Onset	insidious	insidious	rapid	insidious
Characteristics	uniform narrowing of entire, circumference, firm, inelastic, ulceration above, in and below stricture	pale and dry, thick, rigid; ulceration infrequent	hard or soft and spongy, begins as small movable nodule but later fixed	round or oval nodule—pea to an orange; single or multiple; painless; bluish or purple in color, firm to touch; movable and ulcerates regularly. Responds to antiluetic treatment
Laboratory		tuberculosis elsewhere	cachexia and ascites, metastasis	manifestations elsewhere
a. Intradermal test	Frei usually positive	tuberculin positive	Gruskin positive for sarcoma	
b. Stools		tubercle bacilli only occasional		
c. Biopsy of tissue	not characteristic	miliary tubercles	positive for sarcoma	
d. Guinea pig inoculations		shows tuberculosis		
e. Blood				Wassermann, Kolmer positive

appears with loss of weight. Biopsy will confirm the diagnosis.

*Complications and Sequelae.* Usually inflammatory strictures are so progressive that, because of absorption of the retained products, severe toxicity ensues with loss of weight and general debility. Abscess and fistula, frequently multiple, are not uncommon and when present may rupture through the skin into the perirectal tissues, as the ischiorectal fossa and pelvi- or retrorectal spaces, or into adjacent structures, as the vagina, bladder and urethra. Peritonitis may occur from perforation of the ulcers above the peritoneal reflection or complete obstruction may take place.

*Prognosis.* In stricture of the rectum, the prognosis is variable and depends upon the etiology, extent, treatment instituted, age and condition of the patient. The

strictures in which a radical two-stage operative maneuver is performed.

*Treatment.* It should be understood that in every case effort is made to ascertain the cause and any influencing factors; for instance, if the Wassermann reaction is positive, proper antiluetic treatment should be instituted, even though it has no effect on the fibrotic stricture. If the patient is tuberculous, measures should be directed to this angle. An attempt should be made to build up the constitution of the patient since there are usually varying degrees of weakness and loss of weight. As to the diet, it should be nutritious and composed of foods which leave but little residue. Vitamin therapy may be employed to advantage; ordinarily our patients receive B complex approximately 5,600 International Units daily.

*Medicinal Treatment.* Instillations of ichthyol, 10 to 20 cc. of a 25 per cent aqueous solution, twice daily, are soothing to the mucous membrane and will assist in diminishing tenesmus. Irrigations of hot water 110°F., potassium permanganate 1:8000, or S. T. 37 (hexylresorcinol) 1:8 once or twice daily, will tend to cleanse and heal the inflamed mucosa. For topical applications to the ulcerated areas, 5 or 10 per cent silver nitrate, metaphen or 50 per cent para-thio-cresol may be employed. Bleeding areas will often respond to a saturated solution of potassium permanganate. Easy passage of stools is facilitated by the administration of liquid petrolatum,  $\frac{1}{2}$  to 1 ounce, night and morning as indicated. In approximately 250 cases, sulfanilamide was given without noticeable results. Operative cases receiving this drug seemed to progress more satisfactorily. In almost every instance the period of convalescence seemed to be decreased. Eighty gr. were given by mouth daily for two days; thereafter, approximately 40 gr. daily for seven days. When ambulant, patients were given between 10 and 20 gr. daily but were frequently observed for untoward symptoms. Where this drug is employed, close co-operation with the medical department is to be advised. Recently, sulfathiazole has been used, and the results appear more satisfactory.

*Surgical Procedures.* Indications for operative intervention may be enumerated as follows: Marked constrictions not amenable to treatment, or those in which other measures have failed; long tubular strictures or those of the annular variety not within reach of the finger and above the peritoneal reflection, where obstruction is impending, and in the presence of marked constitutional symptoms.

*Perineal Excision with Colostomy.* No maneuver is permanent or ideal in the treatment of these lymphogranulomatous strictures of the rectum except a radical measure. Under this heading probably the most popular is the one-stage abdominoperineal resection of Miles. It is to be

chosen for malignancy although a permanent colostomy must of necessity be established; a proctosigmoidectomy (Babcock)<sup>103, 105</sup> performed by the abdominal or perineal route avoids this by the establishment of a functioning perineal anus. Any intra-abdominal extirpation performed carries an exceedingly high mortality; with colostomy followed by perineal excision the mortality is practically nil. Twenty-seven patients operated upon by the author<sup>106</sup> are living and well even though the second stage in some instances may have been stormy and the convalescence protracted.

*Colostomy. Preliminary Step.* A permanent left inguinal colostomy is established through a muscle-splitting incision. This incision approximately three inches in length is made with its center cutting at right angles an imaginary line drawn between the anterior superior iliac spine and the umbilicus. This places the incision parallel to the fibers of the external oblique muscle and aponeurosis. The incision is made through the skin which is retracted; bleeding points are ligated with No. 35 alloy steel wire or No. 0 plain catgut, and drapes are clamped with towel clips to the skin edges. The external oblique muscle and its aponeurotic fibers are separated in the direction of the fibers and retracted, thus exposing the internal oblique muscle. This and the transversus abdominus muscle fibers are separated and retracted in a similar fashion. The fascia transversalis, extraperitoneal fat, and peritoneum are elevated and incised parallel to the skin incision. The sigmoid colon is found readily by passing the hand into the abdomen along the lateral wall of the peritoneal cavity and then bringing it medially along the lateral leaf of the mesosigmoid. When it has been identified by its anatomical position, appendices epiploicae, haustra, and taeniae coli, the sigmoid is brought out of the wound. Any portion of the sigmoid which is normally mobile by virtue of its mesentery may be selected. With the bowel withdrawn beyond the skin margin a small incision is made perpendicular to the axis

of the gut in an avascular area of the mesosigmoid. A glass rod with rubber tubing attached to one end is passed through this opening and allowed to rest on the skin surface; after this the free end of the rubber tube is passed over the protruding bowel and slipped onto the opposite end of the glass rod. The peritoneum is now closed loosely around the bowel with No. 1 chromic catgut and the internal and external oblique muscles approximated with No. 32 alloy steel wire in an interrupted fashion. Finally, the skin is drawn together with silk or No. 35 alloy steel wire and vaseline gauze tucked snugly around the bowel.

The second step consists of opening the bowel. This may be done immediately but is usually performed between the second and fifth day. Subsequent care consists of daily dressing, cleansing the skin with alcohol, and the application of gauze saturated with mineral oil. Fluids are given by vein and skin during the first forty-eight hours to the extent of not less than 3,000 cc. daily. A liquid diet is prescribed after forty-eight hours provided distention is not marked. Milk should be avoided. Skin sutures are removed between the fifth and seventh day.

*Division of the Colostomy.* This may be done in the operating or patient's room. Without anesthesia the surrounding skin and suture line are protected by gauze or toweling and the protruding bowel divided transversely in its center, using a scalpel, cautery or electric knife, until the glass rod is encountered. Bleeding points are coagulated or ligated with plain chromic catgut. A finger is introduced into the lumen of the upper and lower loop and a few ounces of warm olive oil instilled. This and the administration by mouth of mineral oil are of utmost value in establishing the fecal flow. Thereafter the patient may be given a soft diet and the lower loop irrigated with warm potassium permanganate 1:8000 solution. While the patient may be discharged on the tenth day the irrigation of the lower loop should be continued for a

period of three, six or even nine months which diminishes the degree of infection. The general resistance is improved by the short-circuiting process and methods toward rehabilitation: fresh air, sunshine, good wholesome food, tonics and vitamins.

*Perineal Excision.* Under lumbar analgesia the patient is placed in the lithotomy or inverted position. (In the case of a male an indwelling catheter is tied in the bladder.) The anus is closed with plain silk or catgut after an iodine-saturated strip of gauze is inserted into the rectum. An incision is made from a point one inch anterior to the anal verge on either side of the anus to a site overlying the coccyx tip. The incision is deepened on all sides and the deep fascia denuded. All portions of the levator ani are severed and ligated. When the lateral and posterior aspects are freed, the rectum is carefully dissected from the vagina or prostate. When the lower edge of the prostate is reached the rectum is stripped backward from it until the two seminal vesicles are seen. The stripping is continued, aided by blunt dissection with closed scissors, in order to separate the rectum from the vesicles. Following separation of the ductus deferens and vesicles from the rectum the lateral ligaments are divided and here the peritoneum comes into view. When the stricture involves the summit of the rectum, it is necessary to open the peritoneum. In this case it is nipped with scissors and freed on all sides. The mesosigmoid is divided between clamps and the vessels ligated. A site well above the stricture is selected and the peritoneal and muscular coats of the gut are incised circularly and stripped backward so as to form a wide groove. In this groove one clamp is applied below and another above, following which the bowel is divided with a cautery. The freed segment is removed from the operative fields. The remaining stump is ligated with catgut, the clamp removed, and the closed end of the gut inverted by means of a purse-string suture. Where the peritoneum is opened during the dissection, it is now closed around the

upper segment interruptedly. To avoid an attempt at closing the perineal wound by suture a large sheet of gauze is placed in the wound and loosely filled with a series of cigarette drains. These are removed after the fourth day. Patients are allowed out of bed after the fourteenth day when small hot sitz baths are begun.

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# Thoracic Surgery

## POSTOPERATIVE PULMONARY ATELECTASIS

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ALTHOUGH a century has passed since its first recognition and experimental production, pulmonary atelectasis still constitutes the most common pulmonary complication following intra-abdominal operations. Rink<sup>61</sup> (1938) recently stated that from a series of reported cases, pulmonary complications occurred in 14 per cent of the abdominal operations and in only about 1 per cent of nonabdominal operations, and that the latter as a rule were other than pulmonary atelectasis. These statistics are in accord with those of King<sup>38</sup> (1933) who reported an incidence of 14.3 per cent for the abdominal group and 1.2 per cent for all others. The importance of atelectasis is more appreciated when its relationship to postoperative pneumonia is considered. It is now an established fact, based on experimental and clinical evidence, that unless effective early treatment is instituted postoperative atelectasis is likely to develop into pneumonia. The proof of this statement will be presented later in the discussion dealing with pathologic physiology.

The term, atelectasis, is derived from two Greek words, "ateles," meaning imperfect, and "ektasis," meaning expansion. It was first applied by Jorg<sup>35,16</sup> in 1832, on ideas gained from his father, to a condition of the lungs observed in newborn infants after death. It was not recognized as a (pulmonary) complication following abdominal operations until almost seventy-five years later when Pasteur<sup>57,58</sup> (1908 to 1911) published a series of articles on the subject. The term, "massive collapse of the lung," was originated by Pasteur to designate a type

of atelectasis which involved an entire lung lobe as compared to patchy atelectasis. This differentiation unfortunately was on an etiological basis and subsequently led to considerable confusion when attempts were made to reproduce the condition in experimental animals. To Sir James Barr<sup>5</sup> (1907) goes the credit of diagnosing the condition as a postoperative complication. After ruling out pleurisy with effusion by attempted thoracentesis, a diagnosis of atelectasis was made and the patient recovered "under a course of respiratory gymnastics."

### ETIOLOGY

It is not the purpose of this paper to go into great detail concerning the historical background of the theories pertaining to the etiology of postoperative pulmonary atelectasis. These theories have been thoroughly reviewed by several authors including, among others, Churchill<sup>14</sup> (1925), Brunn and Brill<sup>10,11</sup> (1930), more recently by Moore<sup>52</sup> (1939) and will only be mentioned here in connection with various etiological factors as they are now recognized. Although the etiology of atelectasis has been debated for almost a century, a universal agreement was not forthcoming until within the past two decades. Much of the argument has been as to what factors are most important and which are secondary. The schools of thought have been divided into three groups and will be discussed as such.

1. *Bronchial Obstruction.* As early as 1853, Gairdner<sup>26</sup> was aware of the frequency of "collapse of the lung" and recog-

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nized both the "diffused and lobular" types. He believed that bronchial obstruction which was dependent on a number of secondary factors (i.e., mucus in the bronchi, weakness or inefficiency of the inspiratory power and inability to cough and expectorate) was the essential etiological factor in the production of atelectasis. He thought that the obstruction was of a ball-valve type and that the air was removed by way of the air passages.

Bartels<sup>6</sup> (1861) also favored bronchial obstruction as the primary etiological factor but agreed with Fucks<sup>25</sup> (1849) who was the first to point out that the entrapped air was probably absorbed by the blood. It remained for Lichtheim<sup>44</sup> (1878), through ingenious and painstaking experiments, to prove that the entrapped air following bronchial obstruction was absorbed by the blood. He demonstrated that when the blood vessels were tied no atelectasis occurred. In addition he determined the rate of collapse, and found that complete absorption of pure oxygen occurred from the lungs within forty-five minutes while nitrogen required at least twenty-four hours. As pointed out by Sewall<sup>63</sup> (1921), these experiments did not disprove the possibility of the air being removed from the lung by the ball-valve action of the bronchial plug.

Elliott and Dingley<sup>21</sup> (1914) in a review of eleven patients were among the first to recognize atelectasis as an important postoperative complication. A viscid mucopurulent secretion was found in all instances and bronchial obstruction was thought to be essential for the production of atelectasis, although immobility of the diaphragm was considered as a secondary factor. More recently an abundance of both clinical and experimental evidence (Jackson and Lee<sup>34</sup> (1925), Andrus<sup>3</sup> (1925), Hearn and Clerf<sup>30</sup> (1927), Lee et al.<sup>40,41,42</sup> (1928), Coryllos<sup>18</sup> (1930), Adams and Livingstone<sup>1</sup> (1931), Korol<sup>37</sup> (1931)) has left no doubt that bronchial obstruction is the one primary factor essential for the production of pulmonary atelectasis.

2. *Decreased Inspiratory Force.* Pasteur<sup>55,56,59,60</sup> (1890 to 1914) who was the first strong supporter of this theory, was much influenced by observing pulmonary atelectasis in a number of patients with postdiphtheritic paralysis of the diaphragm. He also believed that paralysis of the bronchial muscles might in some way aid in the production of atelectasis and was among the first to recognize its importance as a postoperative complication.

Briscoe<sup>9</sup> also believed that quiet breathing in the supine position in patients who did not fix their chest with the abdominal muscles, would normally lead to atelectasis.

Likewise Bradford<sup>8</sup> (1917 to 1919) after observing a number of patients with atelectasis following and on the opposite side to trivial war wounds of the chest wall, was inclined to believe that reflex immobility and retraction of the chest wall were the primary etiologic factors.

The fact that atelectasis is by far the most frequent pulmonary complication of abdominal operations (Mastics et al.<sup>48</sup> (1927), Scott<sup>66</sup> (1927)) is supportive evidence for this theory since it has been repeatedly demonstrated (Churchill and McNeil<sup>15</sup> (1927), Muller et al.<sup>54</sup> (1929), Carlson<sup>13</sup> (1932)) that operations, especially in the upper abdomen, reduce both vital capacity (as much as 50 to 60 per cent) and inspiratory effort to a considerable degree.

However, the fact that diminished inspiratory force due to paralysis of the diaphragm or immobilization of the chest wall is insufficient in itself to produce atelectasis is being demonstrated continually in the surgical treatment of pulmonary tuberculosis. Thus it must be regarded as contributory in nature.

3. *Nervous Reflex Contraction of the Lung.* In 1903, Dixon and Brodie<sup>19</sup> produced atelectasis experimentally by the direct action of drugs, and by reflex vagal stimulation causing bronchoconstriction. In order to obtain these results, artificial respiration with little force and with the expiratory phase prolonged was required. If the reverse were tried (i.e., much force

and a long inspiratory phase), distention of the lung resulted.

Scrimger<sup>69</sup> (1921) and Scott<sup>65</sup> (1925) also believed that nervous reflex production of contraction of the bronchial muscles, such as that demonstrated by Carlson and Luckhardt<sup>12</sup> (1920) was the major etiological factor in the evolution of atelectasis. Support for this theory is found in the report by Bergamini and Shepard<sup>7</sup> of two fatal cases of bilateral total atelectasis which occurred during surgery and in whom no bronchial obstruction or secretions were demonstrable at necropsy. More recently Thomas<sup>70</sup> (1938) has reported the experience of Mr. J. E. H. Roberts, who observed the sudden development of atelectasis through an open thorax when intratracheal aspiration was started. It was pointed out by Thomas that cases of atelectasis produced by this reflex mechanism represent a small minority, probably less than 10 per cent, the vast majority resulting from bronchial obstruction by retained secretions.

Although, as stated by Coryllos,<sup>16</sup> no one has given "an exact and precise description of the reflex involved or of the nature of the stimulus itself," it is yet to be proved that a small minority of cases are not the result of this mechanism.

#### PATHOLOGIC HISTOLOGY AND PHYSIOLOGY

*Distribution.* Postoperative atelectasis may vary markedly in amount and distribution. The lower lobes are more commonly involved and may present only small patches of airless parenchyma or the entire lobe may be flabby and contain no air. The process may involve all of both lower lobes as reported by Ball<sup>4</sup> (1928), or as is not infrequently seen may include an entire lung.

The amount and distribution of involvement may vary from hour to hour (Hearn and Clerf) either increasing or decreasing, and may shift from one side to the other by "internal drainage" (Faulkner,<sup>24</sup> 1932). Doubtlessly many cases with the patchy variety of atelectasis clear spontaneously

by the routine changing of the patient's position in bed, with little evidence of its presence manifested. When pathogenic organisms are dammed back by the obstruction, symptoms soon appear. In 1918, Whipple<sup>72</sup> found that a pneumococcus of the type iv group could be cultured from most patients having this complication. Whether these are secondary invaders from the nasopharyngeal flora is not definitely known. However, most available information indicates that they are primary in nature as a result of interference with drainage of the lung.

*Pathology.* Since the prognosis of postoperative atelectasis is usually good, little necropsy material has been available for study. If atelectasis of a lobe is complete, the lung lobe will be markedly shrunken, flabby as a piece of muscle, of a dark reddish-purple color and will sink when placed in water. Microscopic sections reveal approximation of alveolar walls with some mucus in the bronchioles. If microorganisms are trapped by the obstruction, leukocytes and lymphocytes may be seen in the air passages and alveoli. Later stages may show edema of the parenchyma, but it is questionable whether this does not represent the development of pneumonia. Coryllos<sup>17</sup> (1929) believed that not only was there a close relationship between postoperative bronchitis, atelectasis and pneumonia, but that the three conditions represented three stages of a single process. He demonstrated experimentally the similarity of the microscopic appearance and the disturbed circulation observed in atelectasis and pneumonia. Clinical experience has revealed the co-existence of the two conditions. Furthermore, differentiation between the two by means of symptoms, physical and x-ray signs is not infrequently very difficult especially when dealing with the patchy type of atelectasis. Thus it is obvious that when these facts are considered, postoperative atelectasis assumes a much more important rôle.

*Physiologic Considerations.* In the presence of patchy atelectasis without wide

distribution, little alteration of cardio-respiratory function may be effected. However, when an entire lung or only one lobe becomes entirely atelectatic, marked changes may be manifested and may vary directly with the rate of lung collapse.

Reduction in respiratory function which is already encumbered by a lowered vital capacity, is apt to produce dyspnea and hyperpnea. This is all the more likely because of the associated lowering of blood oxygen saturation. Andrus,<sup>3</sup> in 1925, found that thirty minutes following occlusion of the bronchus of an entire lung, the volume flow of blood through that lung was reduced to 31.0 per cent of the total cardiac output, the latter having been increased 14.0 per cent over the preobstruction level. Twenty-four hours later this was decreased to 28.0 per cent, and at the end of one month to 8.0 per cent of the preobstruction level. These results have been substantiated more recently by Moore<sup>53</sup> (1931) and also in our laboratory (Adams et al.,<sup>2</sup> Phillips et al.<sup>60</sup> (1940).

Another striking physiologic alteration produced by atelectasis of an entire lobe or lung, takes place in the pleural cavity. The normal intrapleural negative pressure varies in different locations of the pleural space and with the respiratory cycle. Whereas the average normal is about -6.0 mm. of mercury on expiration and -8.0 mm. of mercury on inspiration, Elkin<sup>20</sup> from measurements made in three clinical patients reported intrapleural pressures as high as -12.0 mm. of mercury in expiration and -15.0 mm. of mercury on inspiration on the effected side with pressures on the opposite side remaining approximately normal. This is similar to the measurements recorded in our laboratory (Escudero and Adams<sup>22</sup>) on dogs with unilateral collapse of an entire lung. Here the intrapleural pressures were altered from a normal of -6.0 and -8.0 cm. of water to -14.0 and -18.0 cm. water on the effected side with also a decrease in pressure on the opposite side to -8.0 and -10.0 cm. water correspondingly on expira-

tion and inspiration. This discrepancy in pressure changes on the side opposite to that of the collapse occurring in dogs as compared to man is explained likely due to the more mobile mediastinum in the former, thus causing a greater shift of mediastinal structures toward the side of atelectasis, a finding also present to a lesser degree in children.

The rate of production of atelectasis of an entire lobe or lung has been much debated. From experimental studies as well as clinical observations it has been found to vary considerably according to the etiological factors, i.e., the type and effectiveness of bronchial obstruction and the character of the respiratory movements which are present in individual cases. Lee and his coworkers<sup>41</sup> (1928) produced atelectasis of an entire lung in dogs within from thirty minutes to three hours by obstructing the bronchus with either 100 per cent acacia or with bronchial secretions removed bronchoscopically from a patient having massive atelectasis of the entire left lung. The dogs were under deep narcosis but the respiratory movements became exaggerated on the side of the chest opposite to the side of collapse. Experiments performed on dogs in our laboratory<sup>71</sup> (1930) demonstrated conclusively that a straining or grunting type of respiration with a check-valve type of obstruction markedly shortened the time necessary for the production of atelectasis of an entire lobe or lung. Serial x-rays revealed marked changes present within a two-minute period. This increased rate of production seems logical since the air in the lung has two avenues of escape, i.e., through the bronchus and also by way of the blood stream. Further, in total obstruction with grunting or straining respiration, absorption of the entrapped air by the blood stream is likely to be more rapid than with quiet respiration since gas absorption varies directly with its partial pressure. In experiments performed at a later date<sup>22</sup> (1933) complete bronchial obstruction in the presence of a normal type of respiration without sedation or

narcosis produced total atelectasis of an entire lung lobe within a three-hour period.

#### CLINICAL PICTURE AND DIAGNOSIS

Postoperative atelectasis characteristically makes its appearance twenty-four to seventy-two hours after surgery but may develop as late as seven to ten days post-operatively. It may be sudden or insidious in onset and varies from mild to severe in its course. There is usually a sharp rise in temperature, pulse and respiratory rate accompanied by various degrees of dyspnea. A cough is usually present and may or may not be productive of sputum. Occasionally, a chill will accompany the rise in temperature, and in severe cases cyanosis may be present. Pain is a variable complaint and whether this represents a combination of atelectasis and pneumonia with pleurisy is not known. As a rule all of these symptoms are not present in each individual case, however, elevation of temperature, pulse and respiration are usually present.

As stated by Brunn and Brill<sup>10</sup> (1930), "the chief characteristic of the physical findings is their variability." They may vary from hour to hour according to the amount of involvement and the type of or absence of bronchial obstruction.

It is generally agreed that the most important finding on physical examination for making the diagnosis of atelectasis is displacement of the heart and mediastinum toward the side of involvement. Unfortunately, this is not always easy to determine in postoperative patients by physical examination and therefore portable x-rays are indicated when the condition is suspected. The above findings are usually accompanied by elevation of the diaphragm on the involved side with limitation of motion of the chest wall and narrowing of the interspaces, the degree of which will be somewhat determined by the amount of lung tissue involved. If the lesion is bilateral, or of the patchy variety, the above findings may be less striking or minimal in degree. In the case of patchy

atelectasis physical examination may be practically normal or consist only of some diminution in breath sounds with or without the presence of râles. However, in the lobar type or when an entire lung is involved, the percussion note will be dull or flat and breath sounds will be altered. If the bronchi are completely occluded, no breath sounds or râles are demonstrable and tactile fremitus is diminished or absent. When the bronchial obstruction is released, loud moist râles and bronchial breathing are present and tactile fremitus will be restored. Many of these findings are similar to those of early pneumonia especially of the bronchial type and for this reason the lesion has undoubtedly been diagnosed as pneumonia when little shift of the heart was noticeable. From experimental work on dogs, Coryllos and Birnbaum<sup>17</sup> (1929) concluded that atelectasis represented a stage in the development of pneumonitis. At the present time it is generally believed from clinical observations that more serious complications such as lung abscess and pneumonia develop from atelectasis if the latter is not promptly diagnosed and properly treated. For this reason, as mentioned above, x-rays of the chest are frequently indispensable. Here also the evidence is not always conclusive, for patchy atelectasis has in the past been frequently diagnosed as bronchopneumonia. Other laboratory tests may be of little help in differentiation between the two conditions since the white blood cells in lobar atelectasis are usually increased to 15,000 or 20,000; and although the sputum is often tenacious in character, it may be quite thin, scanty or abundant and usually contains a pneumococcus of (one of) the type iv group.

Factors which aid most in diagnosis are: (1) awareness of incidence after abdominal operations; (2) time of onset—twenty-four to forty-eight hours after operation; (3) sudden rate of development and severity of symptoms; (4) shift of heart and mediastinum on physical and x-ray examination, and (5) bronchoscopic finding of bronchial obstruction.

## TREATMENT

The treatment of postoperative pulmonary atelectasis may be divided into prophylactic and active. Since the incidence of atelectasis following operations can be materially reduced by attention being given to etiological factors, the importance of prophylaxis is at once apparent.

*Prophylaxis.* As mentioned above the primary etiological factor in most cases of atelectasis is bronchial obstruction usually produced by retained secretions. All other factors are secondary but nevertheless may be of just as much importance, and not infrequently two or more factors may be complimentary in the production of the complication.

1. *Infection.* Since this is an important factor in most pulmonary complications, adequate attention should be given to careful oral hygiene. Furthermore, all major operations of election should be delayed for some time (several weeks) when there is a suspicion of an upper respiratory infection. Placing patients in the Trendelenburg position (about 10 to 15 degrees) until consciousness returns or even as a routine in major abdominal operations will aid in the elimination of secretions from the tracheobronchial tree by gravity. The same principle holds in the frequent change of position in bed (at least every four hours) during the first four or five days following operation.

2. *Drugs.* Since some drugs such as atropine and hyoscine tend to dry secretions, making them more tenacious and difficult to eliminate, they had best be eliminated even when excessive secretions are present (Mathes and Holman<sup>49,50</sup> (1929, 1930) and Thomas<sup>70</sup> (1938)). In our experience this has definitely reduced the incidence of postoperative atelectasis.

3. *Anesthesia.* Since the incidence of this lesion is practically the same following the use of various anesthetic agents, the attention of the anesthetist should be directed toward maintenance of the cough reflex when possible and to the early return

of consciousness following operation. Careful elimination of secretions both during and following operation by gravity drainage or by aspiration through a catheter or a bronchoscope is of paramount importance (Eversole<sup>23</sup> (1940), Mousel<sup>51</sup> (1940)).

4. *Operation.* It is common knowledge that this complication usually follows abdominal and pelvic operations. Thus greater care should be given to this group of patients both in the way of prophylactic treatment as well as watching for its early manifestations following operation.

5. *Excessive Secretions.* In patients with a chronic productive cough due to chronic bronchitis or bronchiectasis particular attention should be given to the elimination of the exudate (secretions) before, during and following operation. This may be accomplished by postural drainage, encouraging the patient to expectorate or by bronchoscopic aspiration prior to operation. To aid elimination by gravity during operation, the patient is placed in a Trendelenburg position by lowering the head end of the operating table to a 10 to 15 degree angle. Aspiration by catheter may be advisable during operation in some cases in which the secretions are profuse. Following operation catheter or bronchoscopic aspiration of secretions from the tracheobronchial tree should be as thorough as possible. On return to the pavilion or room repeated catheter aspirations as described by Haight<sup>29</sup> (1938) will do much to prevent atelectasis and pneumonia. An indication for aspiration is the presence of loud râles and ronchi produced by mucus and pus which the patient is unable to expectorate. If this can not be removed by aspiration with a catheter, a bronchoscope should be inserted and the aspiration carried out under direct vision.

6. *Diminished Respiratory Force.* Since it has been definitely proved that in abdominal operations the respiratory force and vital capacity are markedly reduced, all attempts should be made to prevent further reduction of function by abdominal binders and deep sedation. Henderson<sup>31,32,33</sup>

(1920 to 1929) recommended the inhalation of carbon dioxide-oxygen at intervals following operations in order to re-expand hypoventilated lung tissue. This prophylactic measure has been given an extensive trial with reports of its value being variable, Scott and Culter<sup>67</sup> (1928), Scott<sup>68</sup> (1929), Brunn<sup>10</sup> (1930). However, where hypoventilation is extreme as is the case following some upper abdominal operations, there is little doubt that occasional hyperventilation is beneficial.

7. *Cough.* Since coughing is probably the best natural defence against stagnation of secretions in the bronchial tree, every effort should be made to keep it effective. Due to the production of pain on straining the abdominal wall, the patient is reluctant to cough and expectorate retained intra-bronchial secretions. This can be partially overcome by splinting the wound with a binder which does not restrict respiratory movements and also by the patient using his hands to support the abdomen during the act of coughing (Sommer<sup>64</sup> (1941)). The use of drugs for the relief of pain is important but respiratory depressants should be limited.

*Active Treatment.* When once the diagnosis of postoperative atelectasis is established, active therapeutic measures should be immediately instituted in order to obviate more serious complications.

Since bronchial obstruction due to the stagnation of secretions is present in the majority of cases, clearing of the air passages and re-expansion of the atelectatic lung is the first consideration.

The amount of lung tissue involved and the severity of the symptoms will determine to some extent the therapeutic measures indicated and the urgency of their application. Since marked hypoventilation and an ineffective cough are usually manifested, correction of these factors should be given first attention. Coughing will be more effective in a conscious patient with the head rest somewhat elevated. By supporting the wound with a binder which does not restrict respiratory activity and by

splinting the abdomen with the hands, the patient may be able to raise the obstructing secretions (Saute<sup>62</sup> (1927)). Persistent encouragement in this regard is worth while and in the end is often rewarded. Sedation for the control of pain is helpful in producing an effective cough but respiratory depressants should be used sparingly. Recently, Guis<sup>27,28</sup> (1940) has made use of a paravertebral procaine block of the tenth, eleventh and twelfth dorsal and the first and second lumbar nerves for the relief of pain that interferes with cough, and for improving ventilation of the lung and increasing vital capacity following upper abdominal operations. Overbreathing or hyperventilation may also be obtained by the use of a 95 per cent oxygen and 5 per cent carbon dioxide mixture and should be administered for five minutes several times a day according to the needs of individual patients. This will not only reinflate the hypoventilated lower portion of the lungs but will increase the force and effectiveness of the cough and tend to loosen obstructing secretions.

Drainage of the bronchial tree through gravity by placing the patient in the Trendelenburg position and by change of position in bed from side to side and on the abdomen is of great value in the re-inflation of an atelectatic lung. This is more effective when the secretions are thinned by the use of steam inhalations or expectorants. If the retained secretions are profuse or very tenaceous and the above measures are insufficient to clear the bronchial tree, aspiration by means of a catheter (No. 16 French urethral) inserted through the nose and directed into the air passages should be carried out without delay. The catheter may be introduced more easily with the patient in a semisitting position and passed into the trachea as the patient takes a deep breath, as described by Haight and Ransom<sup>31a</sup> (1941). The patient is then placed in a horizontal or slight Trendelenburg position for aspiration. By having the patient cough and repeating the suction intermittently on several occasions, effective

removal of the secretions is likely. The procedure may have to be repeated several times. If this procedure appears to be

Sedation postoperatively consisted of M.S. Gm. 0.010 and 0.015 during the first day and a similar amount the second day.



FIG. 1. Case 1. A, x-ray of chest before operation. B, x-ray of chest twenty-four hours following operation.

ineffective, or the severity of the symptoms seem to warrant it, bronchoscopic aspiration should be promptly carried out (Haight and Ransom<sup>31a</sup> Leopold<sup>43</sup>). This can be accomplished in the patient's room and may be a life saving measure. Bronchoscopic aspiration has the advantage over catheter aspiration in that the air passages may be more completely cleared of secretions under direct vision.

More recently the use of chemotherapy has been found of value in the management of pulmonary atelectasis. Since bronchopneumonia may readily follow the development of atelectasis, the use of sulfapyradine or sulfathiazole during the reinflation of the collapsed lung is of real importance. The dosage used for this purpose is similar to that employed in the treatment of pneumonia.

The following cases illustrate various clinical features and therapeutic measures employed in the management of pulmonary atelectasis complicating operations:

#### CASE REPORTS

**CASE 1.** A white male of fifty-six in fair general condition was admitted for treatment of carcinoma of the stomach. On August 13, 1941, a partial gastrectomy was made under ethylene-oxygen anesthesia, following M.S. Gm. 0.010 and calcium nembutal Gm. 0.27 premedication.

On August 14 the temperature suddenly became elevated to 104.3°F. (rectal) and the patient felt chilly; the pulse was 125, respiration thirty per minute. A cough with grayish-yellow sputum was noted. On physical examination the patient appeared somewhat cyanotic. Over the lower right chest posteriorly there was dullness with diminished breath sounds and some coarse râles. The heart was deviated markedly to the right. Atelectasis or pneumonia was suspected. The sputum contained many organisms including pneumococci. The white blood count was 13,800 (preoperative white blood count, 6,850). An x-ray revealed the heart and mediastinum markedly deviated to the right and a triangular shadow representing an atelectatic right lower lobe. The right intercostal spaces were narrowed and the right diaphragm was elevated. (Fig. 1B.)

Diagnosis: Massive atelectasis of the right lower lobe and patchy atelectasis of the right upper lobe.

Coughing was made more effective by elevation of the head rest. Hyperventilation was carried<sup>19</sup> out every thirty minutes by rebreathing in a paper bag. Steam inhalations were begun and the patient's position was changed frequently. Sodium sulfathiazole Gm. 3.0 were given intravenously and the same dose repeated three hours later.

On August 15 the patient was much improved. The highest rectal temperature was 102°F. Sulfathiazole (Gm. 3.0) was given intravenously and other therapeutic measures were continued.



On August 16 he continued to improve, rectal temperature was 100°F. Physical and fluoroscopic examination revealed the right

On the following day the temperature was lower and the sputum was raised more easily.

On January 3 the white blood count was



FIG. 2. Case II. A, x-ray of chest taken one week before operation. B, x-ray taken on pneumonia bed on seventh postoperative day. C, x-ray of chest taken nineteen days following operation.

lung to be clear. There was an uneventful convalescence thereafter and the patient was discharged thirteen days postoperatively.

**CASE II.** A white male of seventy-nine entered the hospital complaining of jaundice of two weeks' duration. Three months before admission he had a severe cold which persisted for a month. His general condition was only fair, having lost twenty pounds in weight during the preceding three months. On physical examination his chest was found normal. (Fig. 2A.)

On December 27, 1939, a cholecystgastrotomy for a carcinoma of the head of the pancreas was made under ethylene-oxygen anesthesia following M.S. Gm. 0.010 premedication. Postoperative sedation consisted of M.S. Gm. 0.020 during the first day and a similar amount on the second day.

On December 29 the patient was coughing and had a rectal temperature of 103°F. Physical examination revealed dullness, decreased breath sounds and coarse râles over the midportion of the right lung posteriorly. The heart was shifted to the right. The white blood count was 13,200. The sputum contained a type XX pneumococcus.

Clinical diagnosis: Partial atelectasis of the right lung.

Hyperventilation with 90 per cent of oxygen and 10 per cent of carbon dioxide was carried out and the patient's position in bed was changed frequently. K.I. 10 ggts was administered t.i.d. to make coughing more effective.

10,900. The patient continued to improve but an x-ray of the chest revealed a persistence of the atelectasis of the right lung with deviation of heart and mediastinum to the right. (Fig. 2B.) Sulfapyradine Gm. 1.0 was given every four hours. On January 7 the white blood count was 9,450. An x-ray of the chest was normal on January 15. (Fig. 2C.) The patient had an uneventful course thereafter and was discharged on January 21.

**CASE III.** A white male of sixteen was admitted for a plastic operation on the right mandible. He was in good general condition and on physical examination the lungs were entirely normal.

On February 22, 1941, a bone graft from the right ninth and tenth ribs to the right mandible was made under avertin and ether anesthesia, the latter being administered by intranasal catheter following induction by the drop method. No premedication was given. Postoperative sedation consisted of M.S. Gm. 0.010 on the first day, M.S. Gm. 0.010 and nembutal Gm. 0.09 the second day and M.S. Gm. 0.020, nembutal Gm. 0.09 and codeine Gm. 0.12 on the third day.

On February 24 the rectal temperature became elevated rapidly to 105°F. He became dyspneic and cyanotic; pulse was 150, respirations 35 per minute. Physical examination revealed dullness to flatness over the left chest with breath sounds almost absent and a few râles present at the apex. The heart was shifted over to the left axilla. The sputum contained

staphylococci, streptococci and pneumococci. The white blood count was 19,200. An x-ray of the chest revealed marked shifting of the heart and mediastinum to the left with diffuse spotty graying of the lower three-fourths of the left lung field. (Fig. 3.)

Diagnosis: Massive collapse of the left lower lobe with patchy atelectasis of the left upper lobe.

Oxygen was given by nasal catheter. Hyperventilation with oxygen and carbon dioxide was begun and the patient's position changed frequently to aid aeration of the lung by gravity drainage. Sulfathiazole Gm. 2.0 were given intravenously and followed by Gm. 1.0 every four hours. There was definite improvement on February 25. The rectal temperature was down to 103°F. and the white blood count was 15,600. The following day the temperature was normal. Physical examination revealed a normal chest and the white blood count was 9,750. An x-ray revealed only patchy areas of nonaerated lung with no deviation of mediastinal structures. The course was uneventful thereafter and the patient was discharged on March 5.

CASE IV. A white female of twenty-six in good general condition was admitted for a

expectoration of clear mucus (no other complaints); temperature 102.2°F., pulse 130, respiration, 38 per minute. Physical examina-



FIG. 3. Case III. X-ray of chest made with patient on a pneumonia bed two days following operation.

tion revealed a few râles and an inspiratory stridor over the right chest anteriorly. The white blood count was 15,800 and pneumonia was suspected. The sputum contained a type 19 pneumococcus. An x-ray of the chest revealed

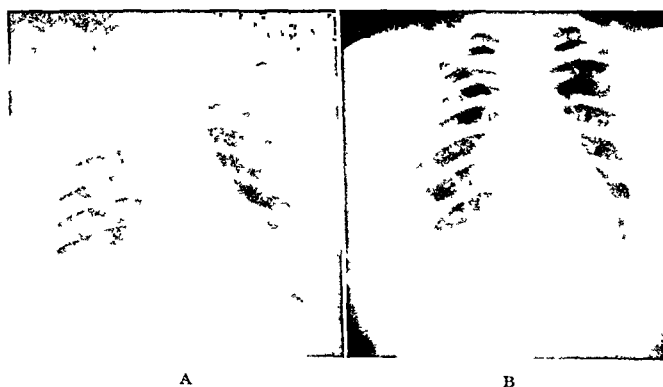


FIG. 4. Case IV. A, x-ray of chest twenty-four hours following operation. B, x-ray of chest made thirteen days following operation.

pelvic operation. There was a history of an occasional pain in the chest with chronic wheezing.

On September 6, 1939, an incomplete hysterectomy and bilateral salpingo-oophorectomy was made under ethylene-oxygen-ether anesthesia after M.S. Gm. 0.020 and hyoscine Gm. 0.00075 premedication given in two doses. M.S. Gm. 0.010 was given following operation to control pain.

On September 7 there was some cough with

an opaque shadow at the right apex, being concave inferiorly. The right diaphragm was elevated.

Diagnosis: Postoperative massive atelectasis of the right upper lobe. (Fig. 4A.)

Cough was made more effective by the use of steam inhalations and K.I. 10 ggts t.i.d. Hyperventilation of the lungs was instituted and the patient's position in bed was changed frequently. Sulfapyradine Gm. 4.0 were given and followed by Gm. 1.0 every four hours.

On September 8 the temperature was only 100.4°F. and the cough was much more productive. On the following day there was marked clinical improvement; the temperature was 100°F., white blood count, 11,500. On September 10, symptoms and signs of atelectasis had disappeared, white blood count was 7,250 and sulapyradine was discontinued. The patient's course was uneventful thereafter and she was discharged on September 18. An x-ray made on September 19 revealed a normal chest. (Fig. 4B.)

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# DIAGNOSIS OF EMPYEMA

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IT is rapidly becoming apparent to surgeons particularly interested in the treatment of acute and chronic non-tuberculous empyema that recent years have brought forth some rather remarkable developments in this field. These developments, however, have not been concerned with new or different methods of surgical treatment. Apparently, the possibilities in these fields have been almost exhausted. There has been, instead, an amazing decrease in the incidence of both acute and chronic empyema. The decrease in the incidence of acute empyema coincides with the development of the various chemotherapeutic agents for the treatment of pneumonia and the decrease has continued as the effectiveness of the various agents has become established and their use has increased. It is interesting to note that in cases in which pneumonia has been treated by specific serums, even though the pneumonia has been treated successfully, no such decrease in the incidence of postpneumonic empyema has occurred. The decreasing incidence of chronic empyema is particularly gratifying because it is due to prevention of chronicity by the early diagnosis and proper treatment of empyemas during the acute stage.

The decreased incidence of acute postpneumonic empyema resulting from the use of chemotherapy in the treatment of pneumonia has been observed too recently to be an important factor in the reduced incidence of chronic empyema. Although the use of chemotherapy in the treatment of pneumonia has resulted in a remarkable reduction in the incidence of acute empyema, it has not completely prevented the development of postpneumonic empyema. The report of the following case illustrates that pneumonia and empyema can occur

while chemotherapy is being employed for another condition:

CASE 1. A woman was admitted to the hospital because of pain which had been present in the lower part of the abdomen for twenty-four hours. The pain had been accompanied by chills, nausea and vomiting. The patient also had had urinary pain and frequency for twenty-four hours before her admission to the hospital. Her temperature was 104°F. and the lower part of her abdomen was markedly tender on both sides. The uterine cervix was very tender and there was a thick yellow discharge. The diagnosis was acute pelvic inflammatory disease. Chemotherapy was instituted; a total dose of 75 to 90 gr. (5 to 6 Gm.) of sulfanilamide or sulfapyridine was administered daily for twelve days. This produced a concentration of 7.8 mg. of the drug per 100 cc. of blood. Four days after the patient was admitted to the hospital, roentgenologic examination of the thorax did not reveal any abnormality, but on the tenth day a similar examination disclosed pneumonia on the right side and fluid in the right pleural cavity. Aspiration was performed several times and *Diplococcus pneumoniae* was found in the aspirated fluid. On the twenty-fifth day after the patient entered the hospital an empyema was drained by means of an open operation. The recovery was complete and uneventful.

Not only has chemotherapy reduced the incidence of postpneumonic empyema but at the Mayo Clinic we have observed that when empyema does develop in spite of chemotherapy it is very different in its clinical manifestations and course from the empyema we were formerly accustomed to seeing. This will be commented on further in subsequent paragraphs.

Although the developments in the surgical treatment of empyema are most gratifying, there are many problems still remaining, as is apparent from any review of literature pertaining to the subject. It

seems likely that the diagnosis of empyema presents as many problems as any other phase of the disease.

Many terms have been applied to the condition under consideration. "Suppurative pleurisy" and "purulent pleuritis" have been suggested since these terms are descriptive of the pathologic process. "Thoracic empyema" and "pleural empyema" have been advocated since they locate the inflammatory process anatomically. "Acute nontuberculous thoracic empyema" is probably the most accurate term that can be applied, but is obviously too long for frequent usage, hence the term "acute empyema" has been generally accepted. Acute empyema can be defined as a collection of purulent fluid within the pleural cavity or interlobar spaces.

It is well known that there is a remarkable variation in the incidence of acute empyema. In general, the incidence seems to parallel the incidence of pneumonia for the year and the virulence of the invading organism prevalent at that time. Empyema occurs most frequently during the winter months. According to Nowak, in 73 per cent of the cases the disease develops during the months from December to May inclusive. It has been a generally accepted fact that empyema will develop in about 10 per cent of cases of pneumonia. In Finland's series of 3,131 cases of pneumococcic pneumonia, empyema developed in 11.7 per cent. Penberthy and Benson have reported 407 cases of empyema among 5,868 cases of pneumonia, an incidence of 7 per cent. Maes, Veal, and McFetridge reported that empyema developed in 11.2 per cent of 6,056 cases of pneumonia observed at the Charity Hospital in New Orleans in ten years. As previously stated, the use of specific serum in the treatment of pneumonia has not appreciably lessened the incidence of empyema while, on the other hand, chemotherapy has materially reduced the incidence. According to Thompson, Edwards and Hoagland, empyema developed in 10 per cent of 121 cases of pneumonia in which the patients were

treated with specific sera while it developed in only four, or 2.8 per cent, of 142 cases in which the patients were treated with sulfapyridine. In a study of 351 cases of pneumococcic pneumonia, Schwartz, Flippin and Turnbull found that empyema developed in 10 per cent of cases in which specific serum was used while it developed in only 2.3 per cent of the cases in which sulfapyridine was used. Our experience at the clinic confirms these observations.

Empyema occurs more frequently among males than it does among females. According to Nowak, the incidence of empyema according to sex is almost the same as the incidence of pneumonia. This author has reported a series of 500 cases of empyema. In this series of cases the ratio of males to females was 2.3:1. Cameron found that the ratio of males to females was 2:1. In a series of 124 cases of empyema in which the patients were past ten years of age, Ochsner and Gage found that the ratio of males to females was 97:27. In a series of 122 cases of acute empyema observed at the Mayo Clinic, the ratio of males to females was 69:53. This ratio is much lower than that reported by most authors. Steinke, who reported a series of 310 cases of empyema in which the patients were children, found that 186, or 60 per cent, of the patients were boys and 124, or 40 per cent, were girls. These figures approximate those obtained at the clinic.

TABLE I  
AGE OF PATIENTS IN 124 CASES OF EMPYEMA

	Age, Years								
	0 to 4	5 to 9	10 to 19	20 to 29	30 to 39	40 to 49	50 to 59	60 to 69	70 to 79
Cases..	21	17	19	16	20	13	10	5	1

No age group is exempt from pneumonia and its chief complication, empyema. Table 1 shows the ages of patients in a series of 122 cases of empyema observed at

the clinic in a period of ten years, namely, January 1, 1931, to December 31, 1940, inclusive. In thirty-eight, or 32 per cent, of the cases the patients were children less than ten years of age. As previously stated, in all of the 310 cases reported by Steinke the patients were less than sixteen years of age. In twenty of the cases the children were less than six months of age. In 200, or approximately 66 per cent, of the 299 cases reported by Wilensky and in 32.4 per cent of the 500 cases reported by Nowak the patients were children less than ten years of age.

Empyema is rarely, if ever, a primary disease. In a great majority of cases it is caused by pneumonia or influenza. This is particularly true in cases in which the patients are children. Michalowicz reviewed 1,450 collected cases of empyema in which the patients were children. Pneumonia was the cause of the empyema in 63 per cent of these cases. In an additional 20 per cent, the empyema followed infectious diseases of childhood. Pneumonia probably was an important etiologic factor in the latter group of cases. In his review of 310 cases of empyema in which the patients were less than sixteen years of age Steinke found that pneumonia was the etiologic factor in 72.3 per cent of the cases. In eighty-nine of the 122 cases of empyema observed at the clinic, the disease followed pneumonia.

Although pneumonia is the most frequent cause of acute empyema, there are many other causes. Pulmonary abscess, bronchiectatic abscess, penetrating wounds of the thorax, pulmonary emboli, pulmonary metastasis, bronchial occlusion by tumors or inflammation, perforation of the esophagus, subdiaphragmatic abscess, or intrathoracic operations may all result in empyema. Empyema may be caused by pleurocentesis performed to aspirate fluid from the thorax, to induce a pneumothorax or to obtain material for biopsy.

Ehlers, who made a collective review of cases of nontuberculous empyema of the thorax reported in the literature, found

that bacteriologic examination of the pus was made in about 3,000 cases. This examination revealed the following organisms: *Diplococcus pneumoniae* in 63.9 per cent, streptococci in 9.4 per cent and staphylococci in 6.5 per cent of the cases, respectively. Combinations of these organisms were not common and the *Haemophilus influenzae* was encountered only rarely. Other organisms that have been found rarely are *Actinomyces bovis*, *Bacteroides funduliformis*, *Eberthella typhosa*, *Escherichia coli* and *Bacillus megatherium*. In a series of 500 cases of empyema reported by Nowak, bacteriologic examination of the pus disclosed the following organisms: *Diplococcus pneumoniae* in 63.4 per cent, hemolytic streptococci in 15.6 per cent and *Staphylococcus aureus* in 4.8 per cent of the cases, respectively. Miscellaneous organisms were found in 9.2 per cent of the cases, and in 7.0 per cent of the cases the infection was "putrid." Steinke made a study of 310 cases of acute empyema in which the patients were children. The results of bacteriologic examination of the pus in 175 cases were recorded. *Diplococcus pneumoniae* was the only organism found in 69.5 per cent of these cases. Staphylococci were the only organisms found in 15 per cent of the cases and streptococci were the only organisms found in a similar percentage of the cases. The following organisms were found in the stated percentage of the 122 cases: *Diplococcus pneumoniae* in 60 per cent, streptococci in 28 per cent and staphylococci in 2 per cent.

The high incidence of infection of the blood stream observed by Nowak is worthy of note. Positive cultures were obtained in 120 of the 221 cases in which an attempt was made to culture organisms from the blood. The following organisms were found: *Diplococcus pneumoniae* in ninety cases, streptococci in sixteen cases and staphylococci in four cases.

In 47.8 per cent of the cases reported by Steinke the disease was situated on the left side of the thorax and in 43.9 per cent it

was situated on the right side. The disease was bilateral in 3.5 per cent of cases and the situation was not stated in 4.8 per cent. In the cases observed at the clinic, the site of the empyema was as follows: on the right side in seventy-four cases, on the left side in forty-six cases and bilateral in two cases. In 51.2 per cent of the cases reported by Nowak the empyema was on the right side, in 42 per cent it was on the left side, in 5.8 per cent it was bilateral and in 1 per cent it was interlobar. In a study of a series of cases collected from the literature, Ochsner and Gage found that the site of the empyema was as follows: on the right side in 435 cases, on the left side in 525 cases and bilateral in twenty-seven cases. Although the site of the empyema is of some interest, it apparently is not of great significance. According to some authors the mortality rate is higher in cases in which empyema is situated on the left side than it is in cases in which the lesion is situated on the right side, but other authors have reported opposite findings.

The diagnosis of acute empyema should not present great difficulty if empyema has been kept in mind as a possible complication, particularly if a satisfactory roentgenogram can be obtained. Because empyema is the most common complication of pneumonia, the possibility of its occurrence must be remembered even in cases in which the pneumonia is treated by chemotherapy. Roentgenologic studies of the thorax should be made at sufficiently frequent intervals during the course and convalescence of pneumonia in order to prevent the development of an unrecognized empyema.

The question as to whether empyema is metapneumonic or synpneumonic is of some significance. Metapneumonic empyema is that type which develops subsequent to the subsidence of the pneumonic process, whereas synpneumonic empyema is that type which develops concurrently with pneumonia. The metapneumonic type is usually caused by the *Diplococcus pneumoniae* and has a better prognosis than the

synpneumonic type, which is usually of streptococcic origin.

An afebrile period of a few days after subsidence of the pneumonic process followed by recurrence of fever has been considered to be pathognomonic of empyema, particularly of the metapneumonic type. The importance of this observation has not been borne out in our experience at the clinic. This sequence of events occurred in only about 30 per cent of our series of 122 cases. In cases in which pneumonia was treated by sulfathiazole and sulfapyridine it has been an even less reliable finding since it has been our recent experience that in cases of pneumonia in which empyema develops in spite of chemotherapy there often is little or no elevation of temperature to indicate the presence of empyema. The following case report is typical of the type of empyema we have been seeing since the development of chemotherapy:

CASE II. A man, thirty years of age, was referred to the clinic with a history of having had pneumonia in the left lung four weeks previously. This had been treated with sulfathiazole. Although the temperature had not risen above 100°F. at any time after chemotherapy was instituted, the patient had failed to improve satisfactorily and had complained of progressive dyspnea. When he was admitted to the hospital the temperature was 99.2°F. It did not go above this level at any time previous to operation. The leukocyte count was 13,700. Roentgenologic studies revealed fluid in the left side of the thorax, compression of the left lung to about half its normal volume, and extensive bronchopneumonia on the right side. Following aspiration of thick pus which contained *Diplococcus pneumoniae*, open operation for empyema was performed on the left side. A pneumococcic empyema subsequently developed on the right side and an open operation was also performed for this condition. The patient made an uneventful recovery.

It is obvious in such cases as this that it would be futile to depend upon elevation of temperature as a clue in the diagnosis of empyema.

The physical signs that are most frequently elicited by examination of the



thorax are flatness to percussion, limitation of thoracic movement, absence of breath sounds and cardiac displacement. Thoracic pain, cough and expectoration are the symptoms most frequently complained of. According to Ochsner and Gage, the signs and symptoms of empyema, expressed in order of their decreasing frequency, are as follows: (1) dullness on percussion, (2) pain, (3) cough, (4) limitation of thoracic movement, (5) absence of breath sounds (6) expectoration, and (7) cardiac displacement. In this regard, Penberthy and Benson have pointed out that physical signs and symptoms, particularly in cases in which the patients are children, are likely to be misleading.

It must be admitted that all clinical signs and symptoms are absent in some cases. In our experience at the clinic, this has been particularly true in cases in which the pneumonia has been treated by the chemotherapeutic agents.

Roentgenologic studies of the thorax will give more accurate information regarding intrathoracic conditions than any other clinical method available. They should be carried out routinely in all cases of pneumonia, both during the course of the disease and during convalescence as it is only in this way that early and accurate diagnosis of empyema can be made. Early diagnosis of empyema is extremely important since it is only by early diagnosis and treatment that satisfactory results can be obtained. Delay incurs the systemic effects of untreated infection, the accumulation of large quantities of purulent exudate in the pleural space with collapse of the lung, development of bronchopleural fistula and other complications. The seriousness of delayed diagnosis and treatment cannot be overestimated. Fitzgerald has commented on the danger to the functional value of the lung incurred by delayed drainage of acute empyema. Horine and Baker have pointed out that in their series of 103 cases of acute empyema 75 per cent of the deaths occurred in cases in which the patients had been ill for more than three weeks. Maes,

Veal and McFetridge, in a review of 100 fatal cases of empyema, found that in forty cases the patients had died of toxemia and exhaustion and that in every one of the cases the empyema had been present a month or more before treatment had been instituted. In the series of 122 cases observed at the clinic, a bronchopleural fistula developed in 25.3 per cent of the cases in which more than 500 cc. of purulent exudate was allowed to accumulate in the pleural cavity before drainage was instituted, as compared to none when there was less than 500 cc. of pus in the empyema cavity.

Lateral roentgenograms of the thorax should be taken in every case in which the anteroposterior views suggest the possibility of empyema. These roentgenograms provide an accurate means of localizing the empyema so that diagnostic aspiration can be carried out without difficulty.

Occasionally, roentgenograms may be misleading. Pulmonary atelectasis should rarely cause difficulty since there is usually mediastinal and tracheal deviation toward the affected side while empyema usually pushes the mediastinum toward the opposite side. However, thickening of the pleura, pulmonary cysts that are filled with fluid, and occasionally solid tumors may produce roentgenographic signs similar to those of empyema.

Laboratory studies other than roentgenologic examination are not of great significance as regards the diagnosis of empyema. There is usually a marked elevation of the leukocyte count with a preponderance of the neutrophilic cells, but this cannot be depended upon, especially in cases in which chemotherapy has been employed.

In cases in which the physical signs and roentgenologic findings are indicative of empyema, the final diagnosis is dependent on aspiration, which should be made at the suspected site of the lesion. Aspiration not only permits accurate location of the lesion so that the most advantageous site for drainage can be chosen but, more important even than that, it can supply a

quantity of aspirated fluid for study of the physical characteristics of the pleural exudate and the nature of the infecting organism. Demonstration of the causative organism by culture of smear should be carried out in every case of empyema in order to prevent improper management of the occasional tuberculous empyema which can closely simulate pyogenic empyema. The importance of this procedure has been stressed particularly by Alexander and Kinsella. The physical characteristics of the pleural exudate are of tremendous importance in determining the proper time for drainage. A variety of methods of determining this time has been suggested. Pearse has suggested that the specific gravity of the pleural exudate should be measured and drainage delayed until the exudate has a specific gravity of about 1.035 to 1.040. Carlson has suggested that the pus may be considered thick enough for drainage when on standing the cellular sediment composes more than 90 per cent of the total volume. Fitzgerald expressed the opinion that surgical drainage should not be carried out until a positive pressure of the pus can be registered manometrically. Suzman said that if manometric readings vary with respiration the infection is widespread without localization and that drainage should be delayed until a fixed manometric pressure indicates sufficient mediastinal fixation to permit safe drainage. According to Berman, the time for drainage can be determined by roentgenoscopic examination of the thorax. All of these methods are of scientific interest but are hardly necessary in the ordinary case of empyema. The rule of thumb suggested by Graham, Singer and Ballon, that is, to delay drainage until the pleural exudate becomes "frank, creamy pus" is a sufficiently reliable guide for all practical purposes.

In the diagnosis of empyema the chief difficulties are encountered in cases in which the disease is atypical, that is, in cases in which the lesion is apical, interlobar or mediastinal and in cases in which there are small, encapsulated pockets of

pus which do not communicate with the main pleural cavity. Fortunately, such cases are rare. Even in these cases, diagnosis should not prove difficult if the clinical signs and symptoms and anteroposterior and lateral roentgenograms cause one to suspect that empyema is present.

In summation, it may be said that a diagnosis of acute empyema requires (1) a suspicion of the possible presence of empyema, (2) an evaluation of the clinical course and physical signs, (3) roentgenographic studies of the thorax in both the anteroposterior and lateral positions at sufficiently frequent intervals, (4) diagnostic aspiration of the thorax at the suspected site of the abscess as indicated by the roentgenologic studies and (5) a study of the aspirated fluid as regards the nature of the infecting organisms and the physical characteristics of the pus.

It should be emphasized that although chemotherapeutic agents have materially reduced the incidence of acute empyema they have not completely prevented the development of postpneumonic empyema. It has been our observation at the clinic that in cases in which empyema has occurred in spite of chemotherapy of pneumonia the empyema has not conformed to the general textbook picture of postpneumonic empyema but has developed later in the course of the illness. Often there has been little or no elevation of temperature and the patient has had no specific symptoms except that he failed to recover his strength as rapidly as desired. The empyema develops insidiously and produces few symptoms except a gradually progressive dyspnea owing to collapse of the lung by the accumulated pleural exudate. The empyema cavity is likely to be multilocular. Cultures of the aspirated exudate are often negative for organisms. The leukocyte count may not be elevated. The reduced incidence of empyema and the changes in its character, however, are no excuse for failure to recognize the existence of the disease when it does occur. The physical and roentgenographic signs of empyema are

not influenced by chemotherapy and these examinations should never be neglected.

Hedblom has stated that empyema may be considered chronic when it shows no marked tendency to spontaneous healing or if it is still unhealed after an arbitrarily chosen period of time. Brock said that empyema may properly be called chronic when the process of obliteration of the cavity has stopped or has become so slow as to be negligible. For purposes of discussion, empyema should be considered chronic if it is known to have persisted for more than three months.

It is probable that if all the potential causes of delayed healing of empyema could be recognized and obviated during the acute stage chronic empyema would not occur. This is, of course, the goal to be sought. Prevention is by far the best treatment of chronic empyema. It must be admitted, however, that the causes of delayed healing and chronicity may be very obscure and even if recognized it may be impossible to remove them. The physician cannot be held accountable for chronicity in cases in which empyema is the result of tuberculosis, actinomycosis, neoplasm or large bronchopleural fistula. However, he should be held accountable in those cases in which chronic empyema results from failure to recognize the empyema during its acute stage and in those cases in which the chronicity is due to inadequate drainage. In the great majority of cases, chronic empyema is due to these causes. Fortunately, the decreasing incidence of chronic empyema indicates that the medical profession is becoming aware of its responsibility in these cases.

In 1923, Hedblom reported 310 cases of chronic empyema which had been observed at the clinic. I have been able to collect 346 additional cases which have been observed at the clinic prior to January 1, 1940. This makes a total of 646 cases that have been observed at the clinic prior to January 1, 1940. In the entire series of 646 cases, the ratio of males to females was almost 3:1. In 482, or 75 per cent, of the cases, the

patients were between ten and forty years of age.

In this series of cases the empyema has been present for from three months to as long as twenty or more years at the time the patients presented themselves for treatment. The empyema had been present for more than six months in about 75 per cent of the cases.

Chronic nontuberculous empyema may be divided into two main groups: (1) latent empyema or empyema that has been present for months or even years without having been recognized and for which surgical drainage has not been attempted, and (2) persistent empyema or empyema which has failed to heal during the arbitrarily chosen period of three months after surgical drainage.

Latent or unrecognized empyema represents a fertile field for prevention of chronic empyema since in about a third of the cases the disease is of this type. The development of latent empyema is almost inexcusable because proper attention and treatment during and subsequent to the course of the disease, usually pneumonia, that has caused the empyema should completely prevent the development of unrecognized empyema. Too often the disease is diagnosed as unresolved pneumonia. This condition is too rare to merit serious consideration and the burden of proof of such a diagnosis should weigh heavily upon the physician making it. Careful physical examination and roentgenologic studies of the thorax in both anteroposterior and lateral positions will indicate the true state of affairs and allow accurate localization of the process so that diagnostic aspiration can be carried out without difficulty early in the course of the disease.

Failure to recognize the presence of empyema and institute early drainage is followed by extremely serious consequences. The lung is collapsed by the accumulation of pleural exudates and becomes fixed in that collapsed condition by a thickening of the portion of visceral pleura forming a part of the cavity and by

a fibrosis within the lung itself. Complete re-expansion is often impossible. Bronchial fistulas develop in a high percentage of cases, according to Hedblom, in about 28 per cent. This not only delays healing after drainage is instituted but also produces irreparable damage to the lung and bronchi and may result in a chronic bronchiectasis. The accumulated pus may burrow through the wall of the thorax and result in an empyema necessitatis or may rarely perforate into the mediastinum, through the diaphragm or even into the opposite pleural cavity. Septic absorption from the accumulated pus produces emaciation, anemia, arthritis, nephritis and osteoarthropathy. The serious results of failure to recognize and properly treat empyema in its early stages become even more apparent when one considers the prolonged illness that results, the multiple and often mutilating operations that are necessary to heal the condition, the pain and expense connected with the whole procedure and the partial disability that may remain even in the most favorable cases.

There is no excuse in the modern practice of medicine for failure to recognize the presence of empyema. It is the most common complication of pneumonia. The diagnosis is not difficult if the possibility of this complication is considered. The diagnostic aids are readily available to every physician. As has been mentioned previously, however, it is important to remember that the postpneumonic empyema that develops in spite of chemotherapy is somewhat different in its course and manifestations from that which develops in cases in which chemotherapy is not used. However, the physical and roentgenographic signs are the same in either case.

Persistent empyema or empyema that has not healed in the three months following drainage makes up two-thirds of all nontuberculous chronic empyemas according to Hedblom. Except for ruling out the possibility of tuberculosis, actinomycosis, neoplasm or complicating factors, the diagnosis presents few problems. In almost

all cases there is a history of continued drainage from a thoracic sinus after drainage for empyema, or a history of healing of the sinus followed by elevation of temperature, cough and pain in the thorax which is relieved by reopening of the sinus and drainage of the empyema cavity.

It must be admitted that improper handling of the empyema during the acute stage is almost entirely responsible for the development of chronicity. That prompt, proper, adequately supervised and sufficiently prolonged treatment of acute empyema will prevent chronicity is evidenced by a report by Bohrer of 265 cases of acute empyema without development of chronicity in a single case.

The fundamental principles of the treatment of acute empyema were firmly established by the researches of the Empyema Commission in 1918 and are as true today as they were then. These principles have been affirmed repeatedly in numerous publications. The difficulties that have arisen have been due to failure to understand and apply the principles as laid down. There has been a failure to appreciate the fact that the anatomic and physiologic changes caused by acute empyema vary with the etiologic agent and that the method of treatment also should vary. It is now generally agreed that in most cases of persistent empyema the disease was treated primarily by closed methods of drainage. Ehlers has listed the most common causes of persistent empyema as (1) too early removal of the drainage tube, (2) persistence of infection because fibrin was not removed at the time of drainage, or because the tube used did not have a lumen sufficiently large to allow adequate drainage, (3) nondependent drainage, (4) the use of a drainage tube which is too long or too short, (5) the presence of a foreign body in the cavity, usually a tube or other drainage material, and (6) delayed expansion of the lung caused by thickened pleura, bronchopleural fistula or fibrosis of the lung. On consideration of these factors it immediately becomes apparent that most of

them could be considered under the single heading of inadequate drainage and that five of the six factors are at least to some extent due to closed methods of drainage. Practically all of these factors could be obviated by the use of open drainage if employed at the proper time. The fault does not lie in the closed method of drainage itself. The method was developed particularly to obviate the dangers of open pneumothorax in cases of synpneumonic empyema of streptococcic origin that were prevalent during the influenza epidemics of 1917 and 1918. It was never expected to provide adequate drainage of a well localized empyema cavity filled with masses of fibrin. Failure of the medical profession to appreciate the limitations of closed drainage led to wide adoption of the method, use of the method in cases in which it obviously was not suitable and a high incidence of persistent chronic empyema.

The decreasing incidence of chronic empyema that I have commented upon earlier is evidence that the problem is gradually approaching solution. It is to be hoped that within the next few years chronic nontuberculous empyema will be a clinical rarity.

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# PRIMARY CARCINOMA OF THE LUNG\*

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THE importance of primary carcinoma of the lung as a clinical problem is well demonstrated by the many excellent contributions dealing with this subject in the past few years. While there is general agreement among surgeons and radiologists that surgical extirpation of the lung (pneumonectomy) combined with the removal of the hilar lymph-nodes is the only form of curative therapy, a discussion of primary carcinoma of the lung would seem to be in order in a volume dealing with diagnosis in surgical conditions.

Carcinoma of the lung accounts for 10 per cent of all deaths due to cancer. An absolute as well as relative increase in the frequency of cancer of the lung is generally conceded.<sup>1</sup> Primary cancer of the lung occurs more frequently in the male. Ninety-one per cent of our last 111 cases were males. Singer's<sup>2</sup> total of 536 cases shows an incidence in the male of 75 per cent.

The age incidence of carcinoma of the lung is not remarkable; the greatest incidence of the disease is found in the fourth, fifth and sixth decades. The age of the patient and the sex become important factors in the diagnosis of certain polypoid bronchial tumors. Brunn and Goldman<sup>3</sup> have emphasized the high incidence in the female of bronchial adenoma (63 per cent were females); and, in addition, 63 per cent of the bronchial adenomas produced symptoms before the age of forty. Gebauer<sup>4</sup> and others have noted the difficulty in making a histologic differentiation between adenocarcinoma of the lung and bronchial adenoma; particularly is this the case when we are basing the diagnosis upon bronchoscopic biopsy material. If the patient is a female and has a polypoid bronchial tumor that has produced symptoms before the

age of forty, we are inclined to make the provisional diagnosis of bronchial adenoma until we prove it otherwise. Since there is considerable doubt if bronchial adenomas ever become malignant metastasizing tumors, the importance of the age and sex factors in relation to polypoid bronchial tumors readily becomes understandable.

Primary carcinoma of the lung occurs more frequently in the right lung than the left, but this fact does not lend much weight in the diagnosis.

The early warning symptoms of carcinoma of the lung have been repeatedly reviewed and stressed by a great number of contributors to this subject. These symptoms should be well known to all doctors by this time. The important fact is that in the great majority of cases of cancer of the lung the duration of symptoms is short; and, as Overholt<sup>5</sup> aptly states, the disease gives quarter for only a short time in its life history and then invariably causes death. There are a few cases of cancer of the lung in which the duration of symptoms has been present for over two years. Goldman<sup>6</sup> collected eleven cases from our own material, and in these patients there existed clinical symptoms of the disease for over two years. Ten of these eleven carcinomas were epidermoid in type. There are, too, those carcinomas of the lung that progress to an incurable stage before any symptoms are produced; fortunately, these cases are few. The perfection of the technic for taking miniature roentgen films of the chest and the low cost per film suggests a potent means for mass examination of our male population over the age of forty. Such a program seems an ideal method to discover the silent form of cancer of the lung.

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There is a truly optimistic expression which is generally present in the various studies of the problem under discussion,

cough, and upon occasion frank hemoptysis may occur. The latter symptom unfortunately is a late one. I say unfortunately



FIG. 1. The roentgen film is not infallible. This is particularly the case when an intrabronchial tumor is located near the hilar structures. A, postero-anterior roentgen film of a patient suffering from severe dyspnea. The only abnormal physical sign was slight prolongation of expiration in the region of the right upper lobe. B, lateral view of the same patient. The hilar density could be caused by enlarged lymph-nodes. C (insert upper right hand corner), artist's drawing of the large tumor (lymphoblastoma, Hodgkin's type) almost completely blocking both right and left stem bronchi in the region of the carina. The obstructive emphysema produced by the tumor is seen in roentgen film A, but there is no roentgen evidence of the presence of an intrabronchial tumor. A tomograph would have demonstrated this tumor. (Fig. 2B.)

namely, carcinoma of the lung in the great majority of cases produces symptoms sufficiently early to permit diagnosis and successful treatment provided the profession does not procrastinate. Delay on the part of the doctor must be eliminated by the acceptance of thoracic exploration for all cases suspected of harboring a cancer of the lung, provided there is not unequivocal evidence of inoperable spread and the patient is a suitable operative risk.

It is pertinent to remember there is no group of symptoms, either subjective or objective, that are diagnostic of carcinoma of the lung. Cough is the most frequent early symptom. It is customarily dry and harassing in the early stages. Later, blood-streaked sputum may accompany the

because frank hemoptysis brings the patient immediately to the doctor, and roentgen films of the chest are routinely obtained of necessity. As the tumor enlarges, and if it is located in a bronchus of sufficient size, symptoms will be produced that are the direct result of bronchial obstruction. Wheezing or asthma-like symptoms may become evident. Infection in the lung parenchyma distal to the obstructing neoplasm will result in chest pains, fever and debility. When the tumor arises out in the periphery of the lung, chest pain may be the initial symptom. This pain is often the result of irritation of the parietal pleura from the adjacent parenchymal tumor. Cough, thoracic pain and hemoptysis are the cardinal symptoms of carcinoma of the

lung. When these symptoms are present in a patient of forty years or over, particularly a male, the presumptive diagnosis

pulmonary suppuration or areas of pneumonitis distal to the obstructing bronchial tumor will produce this same overshadow-

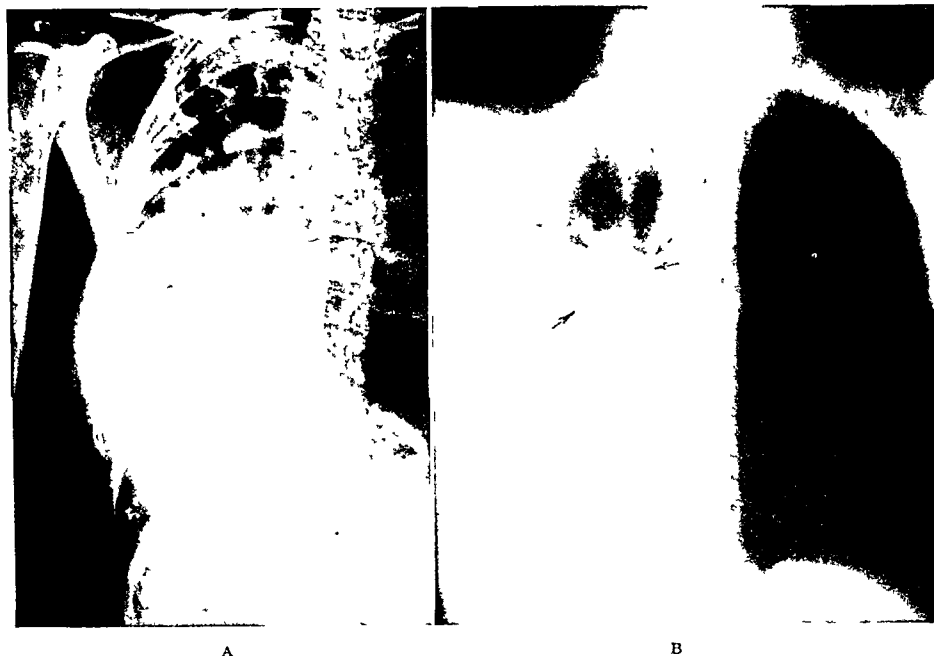


FIG. 2. Tomographic studies. A, hard shot; postero-anterior film. Note the cystic whorls throughout the right lung field and the absence of any definite tumor mass. B, postero-anterior view 8 cm. from the back in the same patient as A. The double arrow points to the large endobronchial portion of the tumor in the right stem bronchus; the single arrows show the extrabronchial lobar extensions. This tumor was a benign bronchial adenoma.

must be carcinoma of the lung until proved otherwise. This dictum must be strictly followed if we are successfully to treat primary carcinoma of the lung.

#### DIAGNOSTIC METHODS

The roentgen film (Fig. 1A, B and C) comprises our first line of defense in the diagnosis of pulmonary neoplasm. The physical findings in the chest are notoriously meager in the early carcinoma of the lung; this is particularly the case when the tumor arises out in the periphery of the lung parenchyma. A small tumor located in the peripheral areas of the lung, some distance from a bronchus of any size, will cast a suspicious density in the roentgen film. When the lumen of the larger bronchi becomes involved by a malignant growth, then atelectasis of the distal lung will create an additional density that often overshadows the tumor density. Chronic

ing effect. Body-section radiography (Fig. 2A and B) has produced the means for the roentgen demonstration of a tumor density that cannot be seen in the ordinary roentgen film.

Serial selective bronchography<sup>7</sup> (Fig. 3) under fluoroscopic control can be employed to demonstrate bronchial defects that are too far distal for bronchoscopic visualization. This method of roentgen examination, using an opaque oil for a contrast medium, can be used to provide additional evidence of bronchial pathology when the routine films of the chest are not conclusive.

It is our practice occasionally to introduce an artificial pneumothorax in order better to outline a suspicious shadow in the roentgen film of the thorax. It is our belief that pneumothorax will sharpen the outlines of a density, especially when the shadow appears in the lung parenchyma. This method of examination using stereo-



scopic roentgen films has been of aid to us in differentiating parenchymal tumors from areas of parenchymal inflammation.



FIG. 3. Serial selective bronchography. Postero-anterior roentgen film of the left thorax. The arrow points to a filling defect in the left lower lobe bronchus. This defect was produced by an intrabronchial tumor. The saccular bronchiectasis is well demonstrated in the left lower lobe distal to the bronchial obstruction.

The statement has been made many times that 75 per cent of the patients suffering from primary carcinoma of the lung will show positive evidence of this pathology when examined by the bronchoscope. Gebauer<sup>4</sup> has concluded in a recent report that bronchoscopy will be negative in 40 to 50 per cent of the cases if this examination is performed at the onset of symptoms. The value of bronchoscopy is not meant to be lessened by Gebauer's conclusion, but rather this statement implies that bronchoscopic visibility of the tumor is delayed positive evidence in over 25 per cent of the cases. When the bronchoscopic examination is negative, other diagnostic methods must be employed if carcinoma of the lung is to be recognized early.

We are not interested in the late bronchoscopic picture of carcinoma of the lung in this discussion. The widening and fixation of the carina, pressure deformity of the

trachea above the carina, or ulceration in a stem bronchus extending up and involving the mucosa at the bifurcation of the trachea, constitute visual evidence of inoperable carcinoma. When there is no endobronchial tumor visible, nor any break or ulceration of the bronchial wall, the bronchoscopist should look for deformity of a given bronchial opening that results from lobular atelectasis. In this latter instance, the bronchial opening may be displaced upward and lateral so that, in the case of the upper lobe, the lobar bronchial opening may not be visible through the bronchoscope. Bronchial fixation and ridging of the mucosa are suggestive findings and require further diagnostic investigation.

Examination of the sputum for malignant tissue or examination of material obtained by needle puncture of the lung have not been used with any degree of regularity in our clinic. In the former instance, Overholt<sup>8</sup> expresses the inclination that cancer cells will probably only become visible in the sputum in the late cases when the tumor is already inoperable or is visible through the bronchoscope. Overholt<sup>8</sup> and Churchill<sup>9</sup> believe that needle biopsy is permissible in cases that are clearly inoperable, but in those cases that may be operable they advise exploratory thoracotomy. Our practice has been very much the same as that advised by Churchill and Overholt. When pleural fluid is present, we routinely aspirate the fluid and examine the sediment by the Mandelbaum method. The fluid is usually replaced by air, and a thorascopic examination of the pleural cavity follows the aspiration of the fluid. It is regrettable that these examinations usually yield positive evidence only when the carcinoma is hopelessly inoperable.

#### DIAGNOSIS BY PATHOLOGIC CLINICAL DIFFERENTIATION

Koletsky<sup>10</sup> and Gebauer<sup>4</sup> have introduced a classification of primary carcinoma of the lung according to the cell type and the clinical course of the carcinoma. They

believe small-cell carcinoma, adenocarcinoma and squamous cell carcinoma are three fundamental types of bronchiogenic cancer. Late in the disease these investigators were able to distinguish these three types of primary carcinoma of the lung in 60 per cent of the cases by combined clinical, radiologic and bronchoscopic investigations.

Of the three types of carcinoma of the lung, the squamous cell cancer is undoubtedly the best suited for surgical removal, and fortunately is the most common of the three types. The relatively slow growth and mild metastatic tendencies favor the possibility of complete removal. Necrosis and cavitation are common in the squamous cell tumor, and frequently render impossible a differential diagnosis from pulmonary abscess.

Graham<sup>11</sup> cannot agree with Koletsky and Gebauer in that he is unable to separate small cell carcinoma from adenocarcinoma as two distinct types of cancer of the lung. There is general agreement among all doctors interested in this subject that the squamous cell tumor is a distinct type and the most favorable from the standpoint of complete removal by surgical interference.

We have not reviewed our own material in an attempt to apply Gebauer's classification and to attest our ability to use this classification to the same advantage as has Gebauer. A pathologicoclinical differentiation in cancer of the lung would seem to be a definite step in the right direction. It may be that in the future, data will be available upon which we can base the correct treatment according to the type of cancer of the lung. This would seem the logical foundation upon which to base future therapeutic improvements.

#### DIFFERENTIAL DIAGNOSIS

Pulmonary tuberculosis, nonspecific pulmonary abscess, lipoid pneumonia, bronchial adenoma and metastatic pulmonary tumors are the more common diseases that simulate primary carcinoma of the lung. A mistaken diagnosis of tuberculosis or lung

abscess often results in the delay of proper therapy. Lipoid pneumonia and bronchial adenoma are frequently misdiagnosed carcinoma, and metastatic pulmonary tumors may be mistaken for primary lung tumors.

One must keep in mind that pulmonary tuberculosis and primary carcinoma of the lung may be present at the same time in the same patient. In addition, primary carcinoma of the lung may closely simulate pulmonary tuberculosis in its mode of onset and radiographic appearance. Pulmonary tuberculosis, on the other hand, may produce a conglomerate nodular tumor in the lung (tuberculoma) that cannot be differentiated from carcinoma except by microscopic studies of the resected specimen.

The majority of the errors in this group have been in mistaking primary carcinoma of the lung for pulmonary tuberculosis. The histories of these patients reveal that the patients were confined to bed rest for many months because the lesion in the lung suggested tuberculosis, yet the tubercle bacillus was never found in the sputum. Often the roentgenologist is responsible for this error; he looks at the roentgen films and calls the lesion tuberculosis. We have made the mistake of accepting the radiologist's report without continued follow-up effort to prove or disprove the radiologist's impression.

Tuberculomas of the lung may exist without the evidence of a positive sputum. A strongly positive tuberculin reaction may give one a clue as to the possible etiology of the nodular lobar density present in the roentgen film. It has already been stated that many times the true diagnosis is not determined until the histologic examination has been completed. Our experience in the surgical treatment of tuberculoma of the lung by lobectomy has been very meager, but a good result can be anticipated if there is no clinical evidence of activity of the tuberculous focus.

Nonspecific abscess of the lung frequently accompanies carcinoma of the lung, particularly the squamous cell type. In some cases it will be impossible to deter-

mine if a carcinoma of the lung is responsible for the abscess until surgical exploration has been carried out. Particu-



FIG. 4. Postero-anterior roentgen film of the chest showing atelectasis of the right lower lobe. Such a roentgen picture is common in carcinoma of the lung. The atelectatic lower lobe in this case was produced by granulation tissue filling the right lower lobe opening. This is a proved case of lipid pneumonia. The treatment in this case was surgical removal of the right lower lobe.

larly is this the case when the bronchoscopic examination is negative. The best aid in the differentiation of these two pulmonary diseases is the recognition upon the part of the doctor that squamous cell carcinoma frequently produces an abscess in the lung. Because the squamous cell carcinoma is slow in growth, an abscess may form in the lung distal to the bronchial obstruction produced by the tumor. Singer<sup>2</sup> has stated the case clearly in these words: "The clinical picture of bronchiogenic carcinoma is frequently masked by the complications. Bronchoscopy should be a routine procedure in every case of pulmonary abscess, and the bronchoscopy should precede any type of specific treatment. When surgical drainage is carried out

in the treatment of an abscess of the lung, a specimen of the abscess wall should be subjected to microscopic examination routinely. There are many cases on record of primary removal of a lung harboring a carcinomatous abscess with recovery. It is preferable to establish bronchial drainage before exploratory thoracotomy, if possible. If one constantly keeps in mind that carcinoma of the lung is often the cause of an abscess in the lung, many of the cases in this group will be explored while they are still operable.

Lipoid pneumonia (Fig. 4) has mimicked primary carcinoma of the lung several times in our experience. Lobar atelectasis, associated with a bleeding, granular bronchial obstruction and infection in the lung distal to the obstruction can all be the result of lipid irritation. When the bronchoscopic biopsy is negative for cancer cells in such a case as outlined above, histologic search for the characteristic foam cells and appropriate lipid stains are in order. Lobectomy or pneumonectomy may be required in the treatment of lipid pneumonia; if the correct diagnosis can be established before operation, one is better able to determine the type of pulmonary resection necessary.

Bronchial adenoma has been mentioned before under the age incidence of carcinoma of the lung. Many excellent contributions have appeared in the recent literature describing this tumor. Goldman,<sup>12</sup> from our own clinic, has added considerable to our knowledge of bronchial adenoma. The tumor we describe as bronchial adenoma has been benign in all the cases we have studied to date. We are of the opinion that bronchial adenomas are definitely not carcinomas of the lung, and are anxious that they (bronchial adenomas) are not classified as carcinomas. Surgical removal of the adenoma will be necessary in many instances when this tumor is present. In our own experience, lobectomy or pneumonectomy will be the procedure of choice depending upon the location of the intrabronchial portion of the adenoma.

Metastatic tumors of the lung offer difficulties in differentiation from primary carcinoma of the lung when the tumor is beyond the range of the bronchoscope and the tumor represents a single metastatic deposit in the lung. Barney and Churchill<sup>13</sup> reported the successful removal of a "solitary" pulmonary metastasis from a primary kidney tumor. The patient was alive and well five years after the removal of the metastatic tumor in the lung. If a single tumor is discovered out in the peripheral lung field and a malignant tumor has been removed elsewhere in the body at some previous time, a possible secondary deposit in the lung of the original tumor should be the reasonable deduction. When careful examination does not reveal tumor deposits elsewhere in the body, exploratory thoracotomy is a sound procedure. Churchill<sup>9</sup> recommends the removal of peripheral nodules *en bloc* and the resection of larger growths by lobectomy or pneumonectomy with intrahilar or mediastinal dissection.

The actual surgical technic in the treatment of carcinoma of the lung is not considered to be within the scope of this communication. The operation of total pneumonectomy with mediastinal dissection technic and the removal of the mediastinal lymph-nodes has become the generally accepted operative procedure for primary carcinoma of the lung. The significant advances in the administration of intratracheal anesthesia and the utilization of cyclopropane gas have lessened the dangers of major intrathoracic operations considerably. The earlier recognition of carcinoma of the lung and the increasing experience of thoracic surgeons should show a progressive decline in the operative mortality and a progressive increase in the salvage rate for this disease.

Overholt<sup>5</sup> reports a salvage rate of 11 per cent (thirteen patients) and an operative mortality rate of 29 per cent (nine patients) in 127 cases of verified primary carcinoma of the lung. Thirty-one of the forty-seven cases subjected to exploratory thoracotomy

were found operable. Churchill<sup>9</sup> notes a salvage rate of 3.2 per cent (five patients) and a hospital mortality rate of 55.5 per cent (fifteen patients) in 155 cases of primary carcinoma of the lung. Twenty-seven of the fifty-two cases subjected to exploratory thoracotomy were found operable. Churchill's figures for hospital deaths in the operation of lobectomy are probably better than those of any other clinic in this country or abroad. In 172 cases of lobectomy for various pulmonary diseases including cancer of the lung, Churchill reports nine hospital deaths, a hospital mortality rate of 5.2 per cent.

These figures are cited to show that there is still much to be accomplished to improve our present results in the treatment of carcinoma of the lung. Churchill's figures reveal that only 17 per cent of the total group of 155 cases were considered operable.

#### SUMMARY

1. Primary cancer of the lung is a frequently occurring tumor and is particularly common in the male.

2. Bronchoscopy will be negative in approximately 40 per cent of the cases of early carcinoma of the lung.

3. Mass examination of our male population over the age of forty, using the miniature roentgen film technic, is suggested as a means to diagnose early cancer of the lung.

4. Pulmonary symptoms appearing in a male forty years of age or older should be considered due to carcinoma of the lung until proved otherwise.

5. Exploratory thoracotomy is a safe surgical procedure and should be the method of choice to establish the diagnosis when the other diagnostic procedures are equivocal.

6. Pneumonectomy, with removal of the mediastinal lymph-nodes, is the only treatment for early carcinoma of the lung.

7. The present results in the treatment of cancer of the lung can be greatly improved by earlier diagnosis of the disease.

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THERE is probably no symptom, except pain, which has a wider significance than dyspnea or shortness of breath. It may be defined as a conscious desire for increased respiratory effort of pulmonary ventilation.

The brief excerpts in this issue have been taken from "Symptoms in Diagnosis" by Jonathan Campbell Meakins (Little, Brown and Company).

# Genitourinary Surgery

## RENAL DISEASE AS A FACTOR IN HYPERTENSION

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IT has long been known that hypertension is related in some way to pathologic change in the kidney. Some observers have claimed that renal disease is present in every case of hypertension. Others have held the opinion that so-called essential hypertension in most cases is caused by undetermined factors other than renal. Although previous investigations had indicated the relation between renal disease and hypertension, the simple experiments performed by Goldblatt and his associates<sup>3</sup> demonstrated this more clearly than any previous experiments. Their experiments showed that impairment of renal circulation, even when unilateral, could be an etiologic factor of hypertension. No physiologic investigation ever has received more definite clinical corroboration. Many case reports have been published which should remove any doubt that hypertension may result from certain types of unilateral renal pathologic changes. These clinical reports also have shown that elevated blood pressure may return to normal and remain so after removal of a kidney in which there is so-called surgical disease.

Not only have the experiments of Goldblatt and his associates and subsequent clinical investigations led to important therapeutic results but, what is of equal importance, they have initiated far-reaching discoveries which eventually may lead to the cause and cure of hypertension. The investigations of Page and his collaborators<sup>4</sup> in this field have been outstanding. These workers have demonstrated that a vasopressor substance which

they have called "angiotonin" is liberated in increased amounts in the renal tissues of hypertensive animals. They have expressed the belief that angiotonin is formed by the enzymatic reaction of renin with a renin activator. Angiotonin causes increase of arterial pressure and decrease of renal blood flow as the result of arteriolar vasoconstriction. In a recent contribution Corcoran and Page<sup>2</sup> made the following statement: "The release of renin which initiates the process appears not to depend on renal ischemia but rather on a change from pulsatile to continuous blood flow within the kidney; that is an intrarenal reduction in blood pressure." Page and his co-workers have also shown that an extractable antipressor substance is present in normal kidneys. They recently have prepared an antipressor substance from normal kidneys which has lowered the blood pressure of patients suffering from severe, fixed hypertension.

Wakerlin and his colleagues<sup>5</sup> recently have demonstrated that hog renin can be used successfully in reducing high blood pressure of dogs. Not only have they been able to cause a reduction of the blood pressure of hypertensive animals by injection of renin but they have also been able to prevent hypertension in dogs by vaccination with renin. They asserted that hog renin reduces the blood pressure of dogs by stimulating the dog's own production of antirenin. They stated that the reduction of blood pressure by hog renin is not, in their opinion, due to the presence in the kidneys of a substance that reduces blood pressure but that the substance is produced in vari-

ous tissues of the body. Although much progress already has been made, it is evident that the last word has not been said in this fascinating search for the etiologic factors involved in hypertension.

After this brief review of recent investigation, let us now consider an etiologic factor of hypertension which has been definitely proved by clinical experience, namely, the so-called surgical kidney. The first question which arises is, how often are patients observed who have a unilateral surgical kidney which causes hypertension? Several clinical reports have been made which grossly exaggerate the incidence of surgical kidney as the etiologic factor in hypertension. A review of cases of hypertension observed at the Mayo Clinic showed that the percentage of patients having clinical or roentgenographic evidence of unilateral "surgical" or non-nephritic renal disease is very small. In the course of routine examination of patients at the clinic hypertension was discovered in approximately 4,000 patients in one year. Clinical evidence of a non-nephritic renal lesion was found in approximately 100 of these hypertensive patients (2.5 per cent). This group of patients was subjected to careful roentgenographic, urologic and clinical examinations and only nineteen (less than 0.5 per cent of those who had hypertension) were selected for operation. In the other eighty-one cases either the renal lesion was regarded as coincident and not related to the hypertension or there were factors which contraindicated operation. These statistics would indicate that only a fraction of 1 per cent of hypertensive patients is amenable to renal surgical treatment.

The question might be asked, how is one to recognize the presence of surgical renal lesions which could cause hypertension? Is one justified in making a roentgenographic and urographic examination, and possibly a cystoscopic examination, in every case in which hypertension is present? We have found that it is entirely unnecessary to do so. It has been our

experience that a surgical renal lesion is seldom present unless at least one of the following conditions is noted: (1) a history of present or previous symptoms indicating involvement of the urinary tract, or (2) the presence of pus or red blood cells in the urine, or (3) evidence of renal pathologic changes in the plain roentgenogram, or (4) positive findings on physical examination suggestive of renal involvement. Excretory urography or cystoscopic examination seldom is indicated unless at least one of the foregoing conditions is present.

It would be simple enough to make a plain roentgenogram of the urinary tract of every patient who has hypertension. The data derived from visualization of the renal outlines in the plain roentgenogram offer a valuable method of detecting surgical lesions of the kidney. A marked difference in the size and shape of the two kidneys should call attention at once to the possibility of a renal lesion. In fact, the diagnosis of atrophic pyelonephritis can be inferred in most cases from an examination of the renal outline. The outline of a small atrophied kidney with median displacement can be seen on one side, with an hypertrophied kidney on the other side.

In the routine urographic study of cases of hypertension, evidence of abnormality often is observed, such as moderate ptosis, angulation of the ureter, slight pyelectasis or slight abnormality of the outline of the calices, pelvis or ureter resulting from previous infection, pregnancy and so forth. Most of these lesions, however, usually are of little or no significance as far as hypertension is concerned. The clinical importance of many of these deformities has been misinterpreted and exaggerated in several articles dealing with this problem. It is only by careful cystoscopic and urologic examination in experienced hands that clinical evaluation of many of the apparent urographic lesions is possible.

When one has found some evidence suggestive of involvement of the kidney, the next step is to determine whether or not renal operation is indicated. The small

group of cases of hypertension in which there is clinical evidence of non-nephritic lesions will include many cases in which operation would be inadvisable for the following reasons: (1) In order to be amenable to surgical procedure, the lesion must be unilateral; evidence of bilateral renal disease would exclude a number of cases immediately from further consideration. (2) Many patients are observed who have a minor degree of unilateral renal disease which very evidently is incidental and not the cause of hypertension. It may be difficult to determine on clinical examination whether a renal lesion is a direct factor or only incidental to the hypertension. In some cases renal surgical intervention might be justifiable on a chance. (3) Patients are observed who have hypertension associated with a surgical renal lesion which may have existed so long that vascular changes and involvement of other organs have occurred to such an extent that removal of the diseased kidney would be inadvisable. (4) Patients more than fifty years of age seldom are benefited unless the hypertension is of recent onset. For these various reasons most of the patients having renal lesions who are first selected are eliminated and as a result it has been our experience that only a fraction of 1 per cent of cases of hypertension remains in which renal operation will offer a chance for relief.

What are the "surgical" or non-nephritic lesions which cause hypertension? In order of occurrence the following types of such renal lesions were observed in our series of cases: (1) chronic and atrophic forms of unilateral pyelonephritis, including those developing after previous conservative renal operations; (2) renal neoplasm; (3) renal lithiasis; (4) hydronephrosis; (5) tuberculosis, and (6) polycystic kidneys. There are other "surgical" lesions involving the kidney that have been observed with hypertension but the lesions cited are seen most often. We have found only two cases in which pressure on or obliteration of the renal artery was the apparent cause of

hypertension. Acute renal infection seldom causes hypertension. That chronic renal infection is a common factor is shown in the higher incidence of hypertension in cases of renal stone and hydronephrosis in which infection occurred. It should be remembered that although the infection may be dormant, changes affecting intrarenal circulation in the renal tissues may result from a previous infection.

When one has decided on renal operation, what permanent benefits can be expected? Most observers are agreed that the best results from renal surgical intervention are obtained among young patients and when the hypertension is of comparatively recent origin. Chute<sup>1</sup> stated it very well when he said that only cases should be selected in which "the cement has not set" and vascular changes have not become permanently established. Permanent recovery was noted in only one of our patients more than fifty years of age. Retinal disease, when far advanced, usually contraindicates operation in adults, but may not do so in children. Another disappointing result is the fact that although the blood pressure may drop after operation, it frequently returns to its former level after a variable period, even as long as a year later. Even in a carefully selected group of patients who have surgical renal lesions, a permanent drop in blood pressure after operation is observed in only about a third of the cases. In other words, the hypertensive patient who has been selected for renal operation should be told at the outset that he has about one chance in three for recovery.

The best results have been obtained in cases of cicatricial renal infection and atrophy such as occur with atrophic forms of pyelonephritis, or after previous conservative renal operation. Approximately 60 per cent of such patients will recover. Approximately 50 per cent of patients who have hypertension and unilateral renal tuberculosis will recover after nephrectomy. The blood pressure will return to normal in about 25 per cent of cases of hyperten-



sion with renal stone or hydronephrosis. More recently in some of the borderline cases in which the hypertension was regarded as being of the so-called essential type, splachnicectomy was performed at the time of nephrectomy. Surgical removal of a diseased kidney which seemed to be the etiologic factor of hypertension did not cause any change in the blood pressure in many cases.

The question may well be raised, is there any particular type of renal pathologic change which favors the secretion of a pressor substance? It apparently is established that intrarenal vascular pathologic change is the essential factor which causes hypertension. Although regions of tissue atrophy with vascular sclerosis of variable extent usually are present, no specific lesion in the renal tissues has been described which always is associated with hypertension. Gross and microscopic examination of kidneys removed from patients who have hypertension may show pathologic changes which are exactly similar to those found in patients who have no elevation of blood pressure. The degree of hypertension is dependent, not on the extent of renal destruction but, as recent investigation would show, on the resulting change in intrarenal blood flow. It is evident that the problems involved are physiologic as well as pathologic in origin.

#### CHRONIC UNILATERAL PYELONEPHRITIS

Chronic infection with cicatricial regions in the renal parenchyma is the non-nephritic renal lesion most frequently observed with hypertension. Acute renal and perirenal infection seldom is an etiologic factor. The chronic renal infection may be either primary or secondary to some other intrarenal lesion such as lithiasis or hydronephrosis. Although primary chronic unilateral pyelonephritis is not a common lesion, yet when present it frequently causes hypertension. It usually is observed in one of three forms, namely (1) unilateral diffuse pyelonephritis with only moderate reduction in size of the kidney and with

limited cicatricial alterations; (2) unilateral atrophic pyelonephritis, with advanced atrophy and diffuse cicatricial changes, or (3) postoperative pyelonephritis developing in a kidney previously operated upon.

*Atrophic Pyelonephritis.* Because the relative incidence of hypertension among patients who have atrophic pyelonephritis is high (47 per cent), this lesion often is cited as the renal lesion which usually causes hypertension. It also is often referred to because of the large proportion of cases in which a permanent reduction of blood pressure follows nephrectomy (70 per cent). However, atrophic pyelonephritis as a clinical entity is not observed very often, as shown by the fact that operation was performed in only forty-three cases at the Mayo Clinic during a ten-year period. This lesion is the result of extensive renal infection and is characterized by widespread atrophy of the renal tissues which causes intrarenal vascular imbalance. Atrophic pyelonephritis should be differentiated from renal hypoplasia. The latter condition is characterized by a similar reduction in size of the kidney but not by the cicatricial and inflammatory changes of atrophic pyelonephritis. The urographic data usually will permit clinical differentiation. The irregular pyelectasis and caliectasis observed with atrophic pyelonephritis usually are in marked contrast to the smooth, infantile outline of pelvis and calices observed with hypoplasia. Hypertension seldom complicates renal hypoplasia.

#### RENAL TUMOR

The relative incidence of hypertension among patients who have renal tumor ranks next to that occurring with atrophic pyelonephritis. It is evident that the age factor must be considered in this group, since eighty-seven, or 63.5 per cent, of these patients were fifty years of age or more. It should be stated that the blood pressure was elevated only moderately (160 mm. or less) in nineteen, or 50 per cent, of the thirty-eight cases studied. Since the blood

pressure returned to normal after nephrectomy in many of these cases, it is possible that an etiologic pressor substance is secreted in the uninvolved portion of the kidney as the result of an abnormal vascular supply caused by intrarenal pressure from the neoplasm. The hypothesis of a pressor substance secreted by the tumor tissue itself apparently has been excluded by the failure to find evidence of such substances in the tumor tissue.

#### RENAL CALCULUS

It may be inferred that renal calculus is not necessarily an etiologic factor of hypertension, since the incidence of hypertension was found to be no greater among patients who had renal calculus than among an equal number of patients taken at random from the clinic's registration. When, however, infection develops, with subsequent intrarenal vascular imbalance, the incidence of hypertension rises abruptly. Hypertension was observed in only 3 per cent of the cases in which there was renal stone but not infection, while in cases in which there was infection it occurred in 37 per cent. The number of pus cells found in the urine in no way indicated the presence of hypertension. Hypertension occurred as often with comparatively few pus cells present as with cloudy urine. In other words, it is apparently the extent to which tissue changes resulting from infection affect the intrarenal blood vessels which matters, rather than the degree of infection. The possibility of the existence of disease in the opposite kidney to account for hypertension existing in cases of unilateral renal stone has been suggested. Against this, however, is the fact that in many cases no evidence of disease in the opposite kidney could be found by the clinical methods available. Furthermore, the incidence of hypertension in cases of bilateral renal stone was no greater than in those of unilateral stone.

#### HYDRONEPHROSIS

Hypertension was found in only fifty-one, or 13.7 per cent, of 372 patients

operated upon for hydronephrosis. Hypertension was observed in only 7.7 per cent of the patients less than fifty years of age who had hydronephrosis. However, when the blood pressure of a patient who has hypertension and who is less than fifty years of age is definitely elevated, it becomes a matter of clinical significance and must be given careful consideration. It is of interest that the degree of pyelectasis apparently was not a factor, since there was no difference in the incidence of hypertension among cases in which pyelectasis was graded 1 or 2 and those in which it was graded 4 (on the basis of 1 to 4, in which 1 designates the mildest and 4 the most severe condition).

#### RENAL TUBERCULOSIS

The low incidence of hypertension among patients who have renal tuberculosis is noteworthy. Elevated blood pressure was noted in but twelve (7.6 per cent) of 158 cases of renal tuberculosis. It is evident that the pathologic changes in the renal parenchyma resulting from tuberculosis are not conducive to the secretion of a pressor substance. Hypertension might be expected to occur as a result of the extensive atrophic changes which take place in the tuberculous kidney that becomes nonfunctioning as the result of occlusion or caseation. However, in a group of thirty-seven such cases hypertension occurred in only five, or 13.5 per cent. There was no drop in blood pressure among the patients who had a nonfunctioning tuberculous kidney and who were subjected to nephrectomy.

#### POSTOPERATIVE HYPERTENSION

One of the most interesting results of our study of cases of hypertension in the presence of a surgical renal lesion has been the disclosure of a group of cases in which hypertension developed after renal operation. In a group of fourteen patients the blood pressure was normal prior to conservative renal operation but hypertension developed over a variable period afterward. Postoperative examination in these cases showed evidence of a reduced renal func-

tion with infection in the kidney subjected to previous operation, while the opposite kidney was found to be normal. After removal of the affected kidney the blood pressure became normal in all of the cases studied. Examination of the removed kidney usually disclosed evidence of widespread destruction of renal tissues, which apparently had resulted from operative trauma and secondary infection. The operations which had been performed previously were as follows: nephrolithotomy, plastic operations for hydronephrosis, nephrostomy for renal drainage, ureterolithotomy, nephropexy, repair of ureterovaginal fistula after hysterectomy, repair of persistent vesicovaginal fistula and sigmoidal implantation of ureters. A postoperative increase of blood pressure apparently occurs more frequently after conservative operation for renal and ureteral lithiasis than after operation for other lesions.

#### RENAL INJURY

Hypertension was noted in only two of thirty cases observed at varying lengths of time after severe renal injury. It might be surmised that cicatricial changes following renal injury might eventually cause hypertension, but a review of such cases at the clinic shows that no change in blood pressure is noted in most cases. It may be inferred, therefore, that in most cases of renal injury either the kidney becomes functionless or the injury is not followed by tissue alterations which cause hypertension.

#### COURSE OF BLOOD PRESSURE AFTER OPERATION

The postoperative course of the blood pressure was followed in 372 cases in which surgical operation was performed on the kidney. All these patients were traced for at least six months and the majority of them for more than a year. Several patients were traced for as long as five years. Preoperative hypertension had been observed in 198 of these cases and the preoperative blood pressure had been normal in 174 cases. Hypertension was permanently re-

lieved by surgical operation for various renal lesions in sixty-five, or approximately a third, of the 198 cases. Hypertension in the presence of surgical lesions of the kidney was relieved more often by nephrectomy than by conservative operation.

In seventeen cases there was a postoperative drop of blood pressure but the hypertension returned within a few weeks or months after operation. A temporary drop of blood pressure, occurring immediately after operation, often is caused by rest in bed and removal of a toxic irritant. In several cases the blood pressure remained normal as long as two years after operation and then returned to the preoperative level. In such cases it may be inferred that primary hypertension existed and had been temporarily increased by a surgical renal lesion. In order to determine the permanent result of the operation, it is necessary to follow the patient's blood pressure for at least two years.

In the group of patients having hypertension carefully selected for renal operation the number of cases in which the blood pressure will be restored to normal and remain so for a year or more after operation is, unfortunately, very small. Even so, one patient whose blood pressure is restored to normal by renal operation would justify a vast amount of clinical search and investigation. It is difficult to find a group of patients who are more appreciative of the benefits they have received than the patients who apparently were cured by this procedure.

#### SUMMARY AND CONCLUSIONS

1. A unilateral, non-nephritic or "surgical" lesion in the kidney is not a frequent cause of hypertension. A review of our records shows that the incidence of such lesions among patients having hypertension that are amenable to operation is less than 1 per cent.

2. Surgical removal of a unilateral renal lesion when present will often relieve hypertension.

3. Urographic evidence of deformity in the urinary tract does not always signify that the renal lesion is an etiologic factor of hypertension. Many renal deformities observed in the urogram do not have any clinical significance. Further urologic examination is necessary to exact interpretation.

4. Factors often are present which contraindicate operation in cases of unilateral renal lesions.

5. No specific type of renal pathologic change is observed with hypertension. The essential factor apparently is an intrarenal vascular imbalance which permits the secretion of pressor substances.

6. The renal lesion amenable to surgical treatment which occurs most often in association with hypertension is chronic unilateral pyelonephritis in its diffuse, atrophic or postoperative forms.

7. Acute cortical renal infection or perinephritic abscess seldom is a factor in causing hypertension.

8. The presence of renal stone or hydronephrosis will not affect blood pressure unless there is secondary pathologic change of renal tissues causing intrarenal vascular imbalance.

9. The rôle of secondary infection is important, since hypertension occurred in many cases in which such infection was manifest. However, the deciding factor apparently is not the degree of infection but the consequent lesions in the renal parenchyma which apparently cause intrarenal secretion of pressor substances.

10. The degree of pyelectasis and back pressure did not seem to be a factor, since the incidence of hypertension was no greater in cases in which pyelectasis was of grade 4 than in cases in which it was of grade 1.

11. Hypertension was observed less frequently in the presence of renal tuberculo-

sis than as an accompaniment of other forms of renal disorders.

12. Bilateral renal involvement, such as occurred in many cases of renal stone, hydronephrosis and renal tuberculosis, was not an etiologic factor in hypertension.

13. Hypertension may develop after a previous conservative renal operation. In many of these cases the blood pressure becomes normal after removal of the affected kidney. In every case of hypertension in which there is a history of previous operation, the possibility of etiologic post-operative renal pathologic changes must be considered.

14. Reduction of blood pressure may exist as long as a year or more after operation and yet hypertension may return. In order to determine whether recovery after operation is permanent, it is necessary to determine the patient's blood pressure for more than a year.

15. A follow-up study of cases in which hypertension was present and in which surgical operation was performed showed that in a third of the cases the blood pressure became normal after operation and remained so for a year or more.

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# INFECTIONS OF THE URINARY TRACT

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THE urinary tract may be involved by most of the bacteria that affect men. There are certain ones, however, which seem to have a definite affinity for the urinary tract, being isolated with monotonous regularity.

The percentage tables of various investigators vary as to the relative frequency with which these organisms have involved the urinary tract. This is due to several factors:

## 1. *Methods Used in Taking the Culture.*

In spite of the volumes that have been written to the contrary, cultures are occasionally made from voided specimens. In the male, with proper cleansing of the glans penis and collection of the mid-voiding in a sterile container, it is permissible, but still open to error. In the female, the most satisfactory specimen is one which is collected in a sterile container through a catheter which is sterilized by autoclaving. (The lumina of rubber catheters do not become sterile by conventional boiling.) Catheters sterilized by prolonged soaking in germicides frequently retain sufficient germicides to inhibit bacterial growth.

## 2. *Methods and Care Used in Subculturing.*

The vigor and rate of growth of bacteria vary; and like the seeds of many varieties of plants, when the ground is overseeded, the rank growth of the more vigorous plants inhibits the growth of the weaker. Unless a definite effort is made, mixed infections may be reported as a pure growth of the dominant organism.

## 3. *Sex and Ages of Patients Involved.*

Statistics of the special organisms involved in urinary tract infection frequently reflect only the organisms found in certain classes of patients and so fail to record a satisfactory cross section of society. The statistics

of one whose practice deals with large numbers of women and children may show an overwhelming percentage of urinary infections of the colon group. One who deals with lusty young males will see many Gram-negative organisms first discovered by Neisser; while those dealing with adults of both sexes with definite foci of infection, will see a larger percentage of Gram-positive cocci in pure culture or combined with Colon bacilli.

The class of patients from which the statistics are made will influence them unduly. For instance, these adult males who reach the urological wards of the general hospitals as the result of urinary retention from an obstructing prostate have usually been examined, manipulated, catheterized and traumatized repeatedly. Their urine, as a result, will present mute evidence of this trauma by the presence of *Streptococcus fecalis*, *Bacillus proteus ammoniae*, and *Bacillus alcaligenes*.

Bacteria occasionally are encountered in the urinary tract as a residuum of a systemic disease: typhoid, para A and B, the dysentery group of bacilli, the Gram-positive bacilli of diphtheria and the *Bacilli welchii*.

The micrococcus is always present in the male urethra and is regarded as a saprophyte. Goldstein believes that it is incapable of producing renal lesions and Cook is of the opinion that it rarely involves the bladder. It is not infrequently the only demonstrable pathogen in mild urethritis of young males.

Approximately 80 per cent of the infections of the urinary tract are of bacillary origin and the remaining 20 per cent are due to the coccic type of organism. Bacillary infections occur several times more frequently than do coccal infections

in the urinary tract of females. Coccal infections occur with equal frequency in both males and females.

#### IDENTIFICATION OF ORGANISMS

When it has been decided that infection is present in the urinary tract, the urine should be centrifuged and a Gram stain made on a smear of the urinary sediment. (Of practical interest is the fact that if the urine is slightly acid, a better stain will be achieved.) This will differentiate the bacilli and cocci, and ascertain as to whether they are Gram-positive or Gram-negative. Gram-positive cocci include the *Streptococcus*, *Staphylococcus*, *Micrococcus* and the *Streptococcus fecalis*. The common Gram-negative invaders, in general order of frequency, are *Escherichia coli*, *Aerobacter aerogenes*, *Pseudomonas*, *Salmonella*, *Proteus*, *Shigella* and *Alcaligenes*. It is impossible to distinguish between these organisms by Gram stain. The usual media for culturing colon bacilli is an eosin methylene blue agar plate. On this media, *Escherichia* grows very readily, producing a metallic luster; the *aerobacter aerogenes* produces large colonies of a pale blue tint, and the *proteus* produces a spreading growth with a pungent odor.

The Gram-positive cocci can be frequently identified by smear alone. The most common invader is the *Streptococcus fecalis* which is elliptical in shape and grows in chains. The bunch-grape massing of the *staphylococcus* and geometrical arrangement of the *micrococcus* are characteristic. The *streptococcus* is usually found singly or in short chains. To identify the cocci by cultural methods requires more extensive equipment, the most satisfactory media being brain broth and blood agar.

#### THEORIES ON METHODS OF INVASION

The possible routes of invasion are as follows: lymphogenous, urogenous, hematogenous, a combination thereof, or direct extension.

For many years, we have accepted the explanation that most urinary infections

are due to an invasion of the urinary tract by the colon bacillus, through the lymphatics, the source being the colon. The facts seem to contradict this as it is hard to correlate the theory with certain known experimental data. With the breaking down of the colon group into its various strains, it has been noted that a majority of infected urines show the *aerobacter aerogenes* strain while cultures of the feces show the *Escherichia coli* strain.

All experimental work attempting to prove a lymphatic pathway between the colon and the urinary tract, has failed. The normal lymph flow is away from the kidney and the colon through groups of nodes which empty into the thoracic duct. India ink injection experiments of McKenzie proved the lymph flow from the urinary tract to be segmental and non-intercommunicating. The lymph flow is directed to the sacral, inferior vesical, superior vesical, internal iliac, and renal groups of glands. McKenzie's conclusions are worth quoting:

"The most striking feature was that the appearance of the ureter suggested that no dye passed up either the lymphatics of the ureteral or of the periureteral network, no matter the site of the original injection. Whether the dye was placed around the intramural portion of the ureter or at the bladder neck was of no significance. . . . That dye injected in small quantities in rabbits to different areas of the bladder wall, different levels of lower ureteral wall, and into the cervix is absorbed and passes to the common iliac group of glands either directly or through interposed small nodes. The dye then passes upwards toward the thoracic duct and the implication from one series was that the dye then passes to the blood stream and to the kidneys."

The principal interest in discussions of bacterial invasion of the urinary tract centers about the various ways bacteria involve the kidney. This interest reflects the recognized fact that infections of other parts of the tract may be painful or dis-

tressing, but with rare exception, not fraught with the dangers accompanying renal infection.

The more one reads of the experimental work on the methods of invasion of bacteria and their extension to various levels of the urinary tract, the more one is driven to the conclusion that the lymphatics play a secondary part and the blood stream a primary one. McKenzie has shown that bacteria from the normal and abnormal bowel pass into the mesenteric lymph glands (Ravenel, Calmetti, Griffith, David and McGree) and thence into the blood stream.

The descent of bacteria from kidney to ureter and bladder by urine flow is obvious. How bacteria ascend from bladder to kidney is not so obvious.

Ascending urogenous infection has been considered a clinical entity for many years. The experimental evidence to support this has been accepted with reservations. The work of Helmholtz seems to be conclusive in proving that bacteria injected into the bladder of rabbits involves the kidney pelvis via the lumen of the ureter. The method of extension into the kidney parenchyma from the pelvis is not so clear cut, and again strong suspicion enters that the blood stream may play a dominant rôle.

In support of Helmholtz's histological observations is the work of Graves and Davidoff who, also working with rabbits, showed that regurgitation of vesical contents into the ureter occurs frequently. The ease with which it occurs, depends upon several factors. I quote:

"Chief among these was good bladder tone which seemed to be indispensable. We learned, for example, that those bladders which were relatively empty and contracted at the beginning of the preparation, produced reflux twice as frequently as those which had been recently distended with large amounts of urine. Moreover, we were soon able to predict the outcome of the experiment by observing whether the bladder wall rounded itself in active resistance to distension, or was becoming

filled passively like a toneless sac. Active pressure usually caused regurgitations, passive pressure, never."

How can this be translated into the understanding of certain infections in humans? Ureteral reflux is a condition that would seem to occur more frequently in infants than adults. In doing cystograms on children, reflux of the media resulting in a cysto-ureteropyelogram is common, although its frequency and significance seem to be moot questions. Campbell reports finding it in only 12 per cent of cystograms done on children and considers it evidence of abnormality. It is possible that reflux accounts for the frequency of ascending infection in infants. The preponderance of infections in female infants over males would seem to indicate that the female bladder more frequently receives pathogens from the outside through the short urethra.

Another pathological condition in humans meeting the experimental requirements for ureteral reflux as outlined by Graves and Davidoff, is the urinary retention due to bladder neck or urethral obstruction in adult males. Ureteral reflux, as indicated by cystograms in this group, occurs only when chronic infection in the bladder has stiffened or destroyed the valve-like action of the bladder and intramural portion of the ureter.

*Bladder.* The bladder may receive bacteria through the ureter from the kidney or by reflux from the urethra or prostate. Prostatic secretion, when abundant, must pass back through the internal sphincter into the bladder. Infection may also spread to the urinary tract from the prostate by way of the blood stream.

The rôle acute inflammations of the bladder play in the production of renal infection by way of the blood stream, is problematical. The work of Macht et al. demonstrating that the bladder exhibits practically no absorptive power, even when damaged by corrosive chemicals, suggests that the bladder does not play an important part in disseminating infection, either by way of the lymph or blood stream.

The low absorptive power of the bladder is in sharp contrast to the absorptive power of the posterior urethra. The ease with which the posterior urethra absorbs is attested to first, by the frequency of general reactions following the instillation of local anesthetics, second, the so-called urethral chill following cystoscopic examination or passage of instruments through the urethra, and third, the occasional chill after voiding through the recently resected prostate. These reactions are due to direct absorption of bacteria or foreign material into the blood stream. W. W. Scott cultured organisms from sixty-two to eighty-two patients who developed fever from urinary infections. Seventy-seven per cent of the infections were bacillary and 23 per cent were coccal. Eighty per cent of the sixty-two had had urethral manipulation and urethral trauma as port of entry.

The most common infection in the upper urinary tract follows the recurring pyuria and bacilluria of the lower urinary tract from infected prostatic secretion when immunity and resistance of the patient is lowered. How this ascent occurs is uncertain, but evidence seems to point to ascending luminal infection of the ureter. Recurring renal infection via the blood stream is of rare occurrence except after urethral trauma.

Infection of the urinary tract by contiguity, is infrequent and study of such cases contributes little to the general knowledge of urinary infections. This infrequency emphasizes how independent an anatomical unit the urinary tract is.

The frequency of involvement of the various portions of the urinary tract increases from above downward. The kidney is the least frequently involved, the urethra most frequently.

It is amazing how much infection can surround the ureter without initiating an urinary infection. The most frequent condition causing pyuria by ureteral involvement from extra-ureteral inflammatory conditions, is appendicitis, with the appendix lying adjacent to the ureter. Tissue

from a girl thirty years of age, dying of uremia and hypertension secondary to a long standing osteomyelitis of the hip showed a severe localized periureteritis from the process in the hip, with marked stricture formation and a grade two caliectasis and dilated ureter above. Yet the urine was microscopically negative and there was no history of recurring urinary infection; this, in spite of gradual destruction of the kidney by the septic process in her hip. The bladder wall may frequently be involved secondarily to inflammatory and malignant lesions in neighboring organs to the point of showing leucocytes and red blood cells in the urine, yet there is little evidence to indicate disease of this type results in more than local involvement. When general urinary infection does occur it is by invasion of the kidney via the blood.

Inflammatory involvement may result in the spontaneous discharge of an appendiceal, diverticular or tubo-ovarian abscess into the bladder followed by spontaneous healing or development of a vesico-intestinal fistula.

#### PREDISPOSING CAUSES TO INFECTION OF THE URINARY TRACT

Clinically, many conditions predispose to urinary infections. Any general consideration must include the factors of immunity and the specificity and virulence of bacteria. The much discussed and little understood immunity factor is important. Any force that upsets the body metabolism lowers resistance and invites bacterial invasion. The most common conditions which disturb resistance are fatigue, chilling and general debilitation. Debilitation may be the result of improper diet, general infection or chronic wasting disease.

Bacteria may often be found in the urine incidental to the bacteremia of a general disease. Since bacteria cannot pass through the kidney without renal damage, actual infection of the kidney must be assumed to have taken place. Such lesions are usually small and parenchymal. They heal



rapidly and only rarely does urinary infection persist after the general infection subsides. Bacteria vary in their degree of virulence and in their specificity. Colon bacilli that are specific in their action on the kidney have been isolated from urinary infections. These organisms, when injected in animals, attack the kidneys and no other organs.

Bacteremia from foci of infection located in teeth, tonsils, mastoid, gallbladder, cervix, prostate and bone, repeatedly expose the kidney to infection. Local factors predisposing to bladder infection are obstruction, trauma and stasis.

Obstruction is defined as interference to the normal outflow of urine. It may be anatomical or physiological and occurs at any level in the urinary tract. Anatomical causes of obstruction to the urinary outflow below the bladder are contracture of the bladder neck, hyperplasia of the prostate, congenital urethral valves, strictures, foreign bodies in the urethra and extreme phimosis. Physiological obstruction to urinary outflow occurs from dysfunction of bladder musculature with spasm of the internal and external sphincters and diminution of the expulsive force secondary to lesions of the spinal cord.

Experimentally, it is impossible to infect the urinary bladder by introducing pathogenic organisms without first producing stasis of urine, tissue damage, or both. This is demonstrated clinically by the procedure of catheterization. It is not feasible to sterilize the male or female urethra in preparation for catheterization. No catheter can be passed through the urethra without carrying bacteria into the bladder. If catheterization is conducted skillfully and with minimum trauma, infections are rare. When bungling and force are substituted for skill, infections are frequent. Painful overdistention of the bladder frequently produces sufficient trauma to the tissues to initiate cystitis regardless of how skillfully catheterization is carried out. The commonest example is the cystitis which frequently follows catheterization of the overdistended

bladder after an operation. Trauma to the bladder at the time of surgery may also predispose it to infection, whether introduced by catheterization or by way of the blood stream.

Stasis of urine is a complication of obstruction or trauma. It develops when a bladder decompensates as the direct result of obstruction and may persist after the removal of obstruction. Stasis persisting after removal of urinary obstruction indicates severe damage of the bladder wall as the result of inflammation, diverticulum formation, or neurological dysfunction. Alkaline urine is an excellent culture medium and when kept in the bladder in the form of residual offers ideal conditions for bacterial growth.

In the ureter, the urinary flow depends upon a peristalsis pushing the urine through a lumen of normal caliber. Efficiency may be impaired by excessive narrowing or excessive dilatation of the ureter. Excessive narrowing of the lumen may be due to extrinsic or intrinsic factors. The most common extrinsic factors are aberrant vessels, fibrous bands compressing the ureter, abnormal mobility of the kidney in the presence of a fixed ureter, producing kinking, and pressure from inflammatory masses in nearby organs. The ureter is normally constricted at the ureteropelvic junction, at the crossing of the iliac vessels, at the broad ligament and where it passes through the bladder. Abnormal narrowing at these points exposes them to trauma when small stones are passed, and when ureteritis has been initiated definite stricture may develop and dilatation occur from the obstruction.

Dilatation is most frequently the result of obstruction of the ureteral lumen by a stone. The forceful contractions against such an obstruction and retention of urine above it may bring about a decompensation of the ureter with resulting dilatation. This may be hastened by an intervening infection, with resulting paralysis and destruction of peristaltic activity. Dilatation may occur in the absence of true

obstruction. This was reported by Braasch many years ago. He described it as a destructive ureteritis involving the ureteral wall. The inflammatory reaction so interferes with normal peristalsis that dysfunction and dilatation results. This ureteritis is ascending and progressive, first involving the lower segment of the ureter. Eventually it will involve the entire ureter and pelvis. Dilatation increases dysfunction producing further impairment of drainage which increases dilatation. Extreme dilatation of the ureter may occur without infection. It is of neurological origin and similar to Hirschprung's disease.

Urogenous infections are those that are conveyed from one part of the urinary tract to the other by the urine or from outside the urinary tract by the same media. Clinically, it is to be distinguished from the hematogenous infection by symptoms of lower urinary tract irritability. The urine always shows the evidence of inflammation: pus, blood and bacteria, at the onset. This type of infection is of the ascending variety and is usually due to an organism of the colon bacillus group. This is the largest single group we have to deal with, and is the common type of infection involving females, infants and adults.

This type of infection is characterized by sudden onset with frequency, urgency, tenesmus, hematuria and a fever usually ranging from 100 to 101°F. The patient is conscious of lower abdominal discomfort and the suprapubic area is tender to palpation. With spread of the inflammation, definite tenderness develops upward along the course of the ureters. Extension to the kidneys is then a matter of hours, and is accompanied by chilling, severe back pain, nausea and high fever.

The course of the disease is usually less violent than in hematogenous infections. If the disease is to be self limiting, it becomes quiescent in about ten days. If urinary obstruction exists previous to the infection, or obstruction develops as the result of inflammatory swelling, the disease may be prolonged indefinitely as a subacute infec-

tion and produce severe destruction and distortion of the obstructed parts. Even in the absence of anatomical abnormality or neuromuscular dysfunction, there is a marked tendency for the condition to become chronic.

Chronic urogenous infection is the result of previous acute urinary infection which gradually ceased to produce symptoms. This persistence of infection may be due to discontinuing treatment before all evidence of the infection is gone and in making periodic urine examinations for several months as insurance against late recurrence. However, such is not necessarily the case. The initial infection may have been so mild that medical care was not sought. Such infection may manifest itself as a mild, periodic bladder irritability for many years. Such cases are exemplified by the patient who had been in bed a year at home for suspected pulmonary tuberculosis and who, upon being investigated urologically, was found to have a low grade colon bacillus infection of the right kidney with beginning caliectasis and ureterectasis of the upper two-thirds of the ureter. No tuberculosis was ever found and the fever subsided with treatment of her urinary infection.

Pyelitis of pregnancy is most typically an acute urogenous type of infection. Eighty per cent of such infections are bacillary. These patients are also susceptible to streptococci and staphylococci infections of focal hematogenous origin, a susceptibility, however, which does not seem to increase with pregnancy.

I see no reason to hunt far afield for explanations as to the etiology. Several conditions are contributory. Many believe that the bacilli pass from the intestinal tract via the lymphatics and thoracic duct into the blood stream, and thence into the urine with minimal initial damage to the kidneys. Some suggest that the greater moisture in the genital tract during pregnancy increases the possibility of infected materials being transferred from the short urethra into the bladder. A fair percentage

of pregnant women are already carrying pus and bacteria in the urine from a silent chronic infection. Whatever the source of the bacteria, the stasis in the urinary tract during pregnancy provides a fertile field for their growth. In the latter half of the pregnant state, definite anatomical changes take place. A physiological dilatation of the ureters occurs by the sixth month. The histological studies of Hofbauer and of Baird show definite hypertrophy of the wall of the lower third of the ureter. They suggest that this is sufficient to produce anatomical obstruction. On the other hand, Traut, Lane and Tratner have made kymographic readings which show a physiological lowering of the muscle tone of the ureter. This lowering of the expulsive force must affect the bladder as well. Incomplete and difficult emptying of the bladder is not uncommon. The institution of daily catheterization of the puerperal patient until she demonstrates her own ability to empty her bladder satisfactorily has diminished acute pyelitis as a complication of the puerperium.

Clinically, the wide fluctuation of the daily temperature in pyelitis of pregnancy indicates stasis of infected material and impaired urinary drainage. This is diagnostically important, as diffuse lesions of the renal parenchyma give a plateau type of temperature curve with minor daily fluctuations, and emergence of the former into the latter may indicate cortical involvement of the opposite kidney by hematogenous spread.

The history of sudden onset of urinary frequency and bladder discomfort during pregnancy, rapidly followed by chills and fever, back pain, pus and bacteria in the catheterized urine specimen, makes the diagnosis. These are the classical history and findings as encountered most frequently after the fourth month of pregnancy.

The new factors which have been introduced into the treatment of urinary infections in general are especially applicable here. Not many years ago pyelitis was regarded as a troublesome though not too

dangerous complication of pregnancy. The most serious result anticipated, unless the infection was of the most fulminating sort, was spontaneous abortion. The patient was kept in bed and treated symptomatically. The urinary antiseptics available were useless in the presence of obstruction, but were administered with varying degrees of faith. If the infection was mild, these measures often sufficed, and were associated with the frequent altering of the patient's posture by the elevation of the head or foot of the bed, until some important observers noticed that such changes made little or no difference in the progress of the disease. But when indwelling catheters of sufficient caliber and accurately placed, were inserted in the kidney pelvis, prompt improvement followed. If catheter drainage was not carried out efficiently fever continued and the disease improved only after miscarriage, delivery, or artificial interruption of the pregnancy. The risk of losing the child was high; the patient had a prolonged, severe illness, and was left with a permanently damaged urinary tract. With the realization of the havoc being wrought by procrastination, it became the accepted procedure to institute immediate ureteral catheter drainage following a chill. Catheters of No. 10 to No. 14 French were used. This was, and at times continues to be, our most satisfactory method of controlling infection and renal damage. However, these catheters are not without danger. A marked foreign body reaction occurs in the ureters with a resultant severe periureteritis. Adequate asepsis in handling the catheter is impossible. *Staphylococcus*, *Streptococcus fecalis*, and other organisms may be introduced into the kidneys from the outside, resulting in superimposed infection with bacteria much more virulent and destructive than the original organisms. The patient may become intolerant to the catheter or they may not be able to dispense with the catheter even after weeks of catheter drainage. If these conditions develop, nephrostomy or pyelostomy are to be considered.

With the advent of the newer bactericides, for the first time we have been able to sterilize the urinary tract in the presence of urinary obstruction. This was first accomplished by Helmholz with the ketogenic diet in the obstructed uropathies of children. However, the ketogenic diet is not satisfactory in pyelitis of pregnancy because of the difficulties of administration. Mandelic acid was the first drug which would abort early urinary infection of pregnancy and sterilize the urinary tract with any degree of regularity.

Sulfathiazole and other sulfonamide derivatives are even more efficient. With such potent drugs at our disposal, there is a definite tendency to rely exclusively on them, with the result that at times, we wait too long to institute catheter drainage. It is an unfortunate fact that bacteria most resistant to the sulfonamide drugs are the ones which cause the most renal damage.

#### WHEN SHOULD THE DRUGS AND WHEN SHOULD CATHETER DRAINAGE BE USED?

If the drug is going to be effective, improvement will be noted within forty-eight hours. This improvement is indicated by a downward trend in the fever and pulse, subsiding renal and bladder tenderness, and lessening of the bacterial content of the urine. If no change has taken place within that time, inlying ureteral catheter drainage should be instituted immediately and combined with small doses of the drug as prophylaxis against outside contamination.

If pre-existing renal damage or lowered renal function is known to be present, ureteral catheters should always be used, but if they prove unsatisfactory, surgical intervention is to be seriously considered.

#### HEMATOGENOUS INFECTIONS OF THE URINARY TRACT

Acute hematogenous infections are caused by bacteria which are brought to the kidney by the blood and produce multiple foci of infection throughout the cortex and medulla. The common infecting organism which we encounter is the

*Staphylococcus aureus*. English observers, however, regard the *Staphylococcus albus* as the most frequent etiological agent. Streptococci may produce the same type of lesion and as I have previously mentioned, the colon bacillus has at times a specific action on the kidney when injected into the blood stream. Bacilli capable of producing this type of lesion must be rare. The portal of entry is either the mucous membrane or skin. The condition occasionally complicates acute infections such as pharyngitis, furuncles, carbuncles, osteomyelitis, etc. The source may also be such chronic foci of infection as the teeth, the tonsils, the gall-bladder, cervix, or prostate. A surgical operation on infected tissues may be the initiating event.

These hematogenous infections may be classified according to their severity into two groups: acute and subacute. In the acute there is a sudden onset with diffuse, upper abdominal pain followed by nausea, vomiting, collapse and coma. Fever, pulse rate and leucocytosis will be high. All the signs of sepsis dominate the picture. The condition is usually associated with a recent pyogenic lesion of the skin, as a boil, carbuncle, or septic wound. These may be healed at the time of onset; and if definite inquiry as to the recent occurrence of one of these lesions is not made or the patient is unable to give a history, this fact may not be elicited. To complicate the diagnosis, the urine shows no pus or blood. There may be the usual trace of albumin which can occur in any febrile illness. The two distinguishing features are: (1) Pain and tenderness in the costomuscular angle. This may be difficult to elicit, but should be present before the diagnosis is made. The habit of using a forceful blow over the renal area in attempting to prove this tenderness is to be condemned. The method is inaccurate. It causes unnecessary pain and seems capable of doing actual harm. (2) The other finding is the regular occurrence of cocci in the centrifuged, stained sediment of the catheterized urine specimen. (Cultures are usually negative.)

As the disease progresses, it may be followed by pain in the renal areas. This may be bilateral though usually it is unilateral. As the infection regresses in one kidney as indicated by disappearance of tenderness, it may invade the opposite kidney and be followed by identical clinical symptoms experienced in the other kidney. The disease is usually self limiting, running a febrile course in five to ten days. As the fever subsides, or if the course is prolonged, pus may appear in the urine, with or without *Bacillus coli*. This is interpreted as spontaneous drainage of cortical abscesses into the tubular system of the kidney. The *Bacillus coli* are thought to be secondary invaders.

If the course is prolonged, even though the general level of the fever falls and begins to fluctuate, a carbuncle of the kidney or parenchymal abscess may be developing.

The subacute type may begin insidiously with backache and persisting low-grade fever of  $99\frac{1}{2}$  to  $101^{\circ}\text{F.}$ , and with a leucocytosis under 15,000. Costomuscular angle tenderness will be elicited and cocci demonstrated in the Gram stain of the urine. If the course is protracted, a search for a focus of infection should be made.

#### PERINEPHRITIC ABSCESS

Perinephritic abscess is a collection of pus surrounding the kidney. It is a complication of renal cortical inflammation. The extensive perinephritis that exists in these infections usually develops as an extension of a cortical abscess into the perinephritic fat. The rapid healing power of the kidney often results in healing of the renal cortex, while the low immunity of the perinephritic fat allows for continual development of the abscess as an independent process.

The early signs and symptoms are identical with carbuncle of the kidney or of a small cortical abscess. As the process becomes older and more localized, the fever recedes and the daily fluctuation may not exceed one to two degrees. Night sweats

are frequent and flank pain, tenderness and leucocytosis are the rule. Regular examination of the painful area will reveal a mass of increasing size and a progressive increase of the rigidity involving the muscles of the upper abdomen of the involved side. Difficulty in walking and painful extension of the thigh indicates extension of the abscess into the iliopsoas muscle. The kidney, in advanced perinephritis, has usually recovered its function, and excretes normal uninfected urine. The x-ray findings are definite. The plain negative may show fuzzing and an increase in size of the renal shadow, loss of the iliopsoas shadow, loss of normal renal mobility with respiration and elevation of the diaphragm on the affected side. Pyelo-ureterograms are negative or show displacement and pressure deformity from an extrarenal mass. The treatment is surgical drainage. Many abscesses are multilocular and thorough perirenal exploration is necessary at the time of surgery.

In the acute infections, three questions immediately arise: Is there pus in the urine? What type of bacteria are present? Is there any obstruction to urinary outflow? The first two questions are answered by microscopic examination and Gram stain of the specimen of urine obtained through a catheter and centrifuged at high speed. The catheter will also determine whether there is bladder neck obstruction with residual urine in the bladder. The question of urinary tract obstruction above the bladder can be determined either by cystoscopy or intravenous pyelography. If there is pus in the urine or if there is presumptive evidence of urinary obstruction, a plain x-ray of the kidneys, ureters and bladder, followed by cystoscopic examination, is the procedure of choice. If the urine is free of pus and urinary obstruction is not anticipated, intravenous pyelography often gives all the desired information.

When cystoscopy is employed, it should be accomplished as rapidly and with a little disturbance to the patient as possible. Preliminary injection of indigo carmine is

helpful. Its prompt appearance in good concentration indicates that obstruction, if present, is not complete and the inflammatory process has not involved the kidney sufficiently to cause it to cease functioning. I have never observed an acutely inflamed kidney that demanded surgical removal as long as it was able to excrete dye or the organic iodides.

#### MANAGEMENT

In this day of specific therapy of infections, the importance of intelligent attention to the general management of urinary infection is often neglected. It is well to remember that these conditions were successfully treated from the patient's standpoint long before we had our present drugs. The continued use of alkaline therapy is largely based on the relief it affords the patient of nausea and bladder irritability and not for any specific effect on the bacteria of which it possesses none. Immediate attempts should be made to relieve the patient of his pain. Opium, or its relaxing alkaloids papaverine and pantopon, take preference over morphine or codeine. The azo dyes are useful in allaying bladder pain by their anesthetic action on the bladder mucosa. Their action as a bactericide seems negligible. Bladder lavage with normal saline or isotonic boric solution, followed by the instillation of one-half ounce of metycaine or the colloidal silver salts, will give relief and allow time for the action of the opium derivatives. An intramuscular injection of an ampoule of calcium gluconate or 5 cc. of deproteinized insulin free pancreatic extract is helpful.

Heat in any form gives relief from discomfort. The local application of warm towels to the perineum, sitz baths, and infra-red lights can be used. Short wave diathermy applied with external electrodes or with combined external and vaginal or rectal electrode is especially effective. Considerable importance should be attached to the control of bladder spasms. The satisfactory control of these spasms is necessary

in localizing bladder infection and in preventing renal involvement.

Except as an adjunct to specific therapy, in the acutely ill, special diets are of no value. Small frequent feedings are more successful than three daily meals. See that favorite articles of food that the patient likes (not the physician) are always available and are placed before him when his fever is receding or between febrile reactions; unless a previously known sensitivity for spices or condiments exists, do not omit them; keep the food as appetizing as possible. Fluids are of great value. They combat toxemia by keeping up the tissue fluids and promote drainage by mechanically irrigating the urinary tract. A chart of the fluid intake and urinary output should be kept and the average daily output should be between 2,000 and 3,000 cc. of fluids; this may require an intake of 4,000 to 5,000 cc. This amount is too much to ask the patient to drink. It is less burdensome and more effective when administered intravenously. Fluids are best administered intravenously in isotonic concentrations. This is more important in the aged than the young. If concentrated solutions are used, 5 per cent glucose in normal saline is the solution of choice. Any danger of overloading the circulation with intravenous fluids can be avoided if the lung bases are checked for moisture before each administration. Excess chlorides and tissue overloading may be avoided by watching for edema. Pressure on the skin of the forehead will leave an impression of the whorls of the thumb pads in early edema. If this occurs, lower the fluid intake and use solutions without sodium chloride. Multiple small transfusions help to combat toxicity and should be used to combat progressive anemia in the hemolytic infections.

All patients with infections of the urinary tract should have sufficient urological investigation to determine the types of infecting organisms, the parts involved, and the presence or absence of obstructions to the urinary outflow. The proper time to make the investigation and the thorough-

ness of it depends upon the stage of the illness and the clinical judgment of the physician.

When an ureteral catheter is passed up the affected side and an impassable obstruction is encountered or definite retention in the pelvis of the kidney is noted, adequate drainage above the obstruction must be established and immediate surgical exploration may be indicated if the obstruction is complete. When an inlying catheter is placed, it should be at least No. 8 or a No. 10 French, and should be adjusted by the x-ray for most efficient drainage. When stricture or stone blocks the passage of a catheter, immediate surgical drainage by nephrostomy or pyelostomy is indicated. When there is no retention of urine in the kidney pelvis, I cannot too strongly condemn the routine placing of inlying catheters. No purpose is served and the urinary tract is thrown open to the trauma of a foreign body and the possibility of receiving infecting organisms more virulent than those of the existing infection.

Active etiological foci of infection are not common in the acute infections. They are much more common in the recurrent sub-acute and chronic infections. They should be diligently sought for and eradicated when present.

The acute parenchymatous infections at times require nephrectomy as a life saving measure. Increasing conservatism has been exercised in this condition with equally good results. Since the advent of the sulfonamides, the indications for surgical removal of the infected kidney are increasingly rare. However, a persisting unilateral infection as indicated by constant unilateral costomuscular angle tenderness, increasing lethargy and toxicity and a steadily rising pulse to 100 or above, which fails to fall with the slight recesses in fever, is an absolute indication for nephrectomy.

Fever and unilateral tenderness in this type of infection lasting over ten days, is strong evidence of cortical necrosis or perinephritic abscess, and indicates surgical exploration. However, one must be certain

that the continued fever is not caused by a secondary cortical infection developing in the opposite kidney.

#### CHEMICOTHERAPY

The past decade has been marked by a great advance in the development of drugs and understanding of the principles by which older drugs are more effective and by which certain conditions may be produced in the urinary tract to inhibit and destroy bacteria. Of added importance has been the detailed bacterial studies of infected urines, the isolation of the various types and strains of bacteria to varying degrees of acidity, alkalinity and concentrations of proposed bactericides.

The most effective bactericides in common usage today are divided into two main groups: those which depend upon acidification of the urine for their action, and the sulfonamide compounds.

It has been known for years that increased acidity of the urine inhibits bacterial growth. The importance of this has been emphasized in recent years. Acid urine with a hydrogen ion concentration of 5 or below inhibits many of the common bacteria found in urinary infections and indeed, is at times bactericidal for some strains of the colon bacillus. One of the most efficient urine acidifiers is ammonium chloride, preferably given in enteric coated tablets. Four Gm. a day is an average dose that is usually well tolerated. It may be increased to 6 Gm. a day without producing too much gastric irritation and if necessary this dosage may be continued for several weeks. The use of this drug alone will often give clinical relief of burning and frequency of urination within eight to twelve hours. It is much more effective if combined with mandelic acid or methenamine.

Methenamine is the only one of the older drugs that is effective with any degree of regularity. Its greatest drawback is the frequency with which the formaldehyde produces bladder pain and irritability before bacteriostasis can be produced. To

be effective a daily dosage of 3 to 6 Gm. must be used and the urine must be kept at a hydrogen ion concentration of 5 or below.

Mandelic acid is our most efficient urinary antiseptic outside of the group of sulfonamide compounds. It is an organic acid similar in action to beta-oxybutyric acid which is produced by the ketogenic diet. It was introduced by Rosenheim as a substitute to overcome the technical difficulties of administering the ketogenic diet. It is excreted unchanged by the kidneys into the urine. At a urinary hydrogen ion concentration of 5 to  $5\frac{1}{2}$  and a concentration of  $\frac{1}{2}$  to 1 per cent, it is bactericidal for all the Gram-negative bacilli found in the urinary tract. It is equally effective for *Streptococcus fecalis* and *Staphylococcus aureus*. Clinically, it is less effective in proteus ammonia infections, because of the difficulty in obtaining the proper urinary acidity.

One of the most potent reasons for the dissatisfaction with the drug is gastric irritation, nausea and vomiting. This is frequently caused by using the more irritating ammonium salt of mandelic acid. The combined enteric coated tablets of mandelic acid and ammonium chloride are less irritating, but have the inherent disadvantage of a combination tablet. The dosage rates of the two drugs cannot be varied and to get the proper therapeutic amount, the patient has to take twenty-four or more of the tablets daily.

Calcium mendelate has the advantage of producing an acid urine as well as one which contains the mandelic acid but it may be necessary to reinforce its acidifying properties with ammonium chloride.

The most satisfactory results have been attained with the sodium salt of the drug, given in a 10 per cent solution and the acidity of the urine controlled by the separate administration of 0.5 Gm. enteric coated ammonium chloride tablets. This is admittedly more cumbersome than a streamlined tablet containing both drugs but it has definite advantages. Proper

acidification is easily obtained, adequate amounts of mandelic acid are ingested, and gastric irritation occurs less frequently from the sodium salt than the calcium and ammonium salt.

A prescription suggested by Clark some years ago follows:

Mandelic acid.....	48 Gm.
Na HCO (3).....	25.6
Lemon syrup.....	90 cc.
Aqua q.s.ad.....	480 cc.
Sig. 2 tbsps. after meals and at 8 P.M.	

This should be combined with 8 to 16 of the 0.5 Gm. enteric-coated ammonium chloride tablets daily. They are best tolerated before meals.

This treatment is of no value in the presence of renal damage, because the damaged kidney is unable to excrete the drug in sufficient concentration to produce bacteriostasis. It must be used with great care in Bright's disease as it may further depress renal function, elevate the blood urea and increase hypertension. Coarsely granular casts may occasionally be noted in the urine during administration. This is a sign of renal intoxication and is an indication to lower the dosage or withdraw the drugs.

It is not a drug to be taken in small amounts over a long period of time. It should be given in full doses in definite courses not to exceed ten days, followed by a period of rest and then by another course if necessary. If two trials fail to sterilize the urine, further attempts will be unsuccessful.

When this drug is being used, the patient should be placed on an acid ash type of diet and fluids limited to about 1,000 cc. daily. Acidification therapy with administration of mandelic acid is especially valuable in the acute nonspecific infections of the lower urinary tract with or without lower urinary retention. Complete symptomatic relief is frequently a matter of hours and sterile, pus free urine, is obtained in several days.

Five years ago, sulfanilamide was added to our armamentarium. Since then, a series of the sulfonamide type of drugs have



followed in rapid succession. The present favorite is sulfathiazole, which seems to be the most effective clinically. These drugs are especially adaptable to the treatment of urinary tract infections because the drug can be excreted in therapeutic quantities by kidneys too damaged to get any effect from the use of mandelic acid and acidifying drugs and incredibly small doses will exert a bacteriostatic action on the urine. These clinical observations have been emphasized experimentally by Helmholz, Cook and others. They have definitely shown that doses as low as 5 to 10 gr. daily are clinically effective in all of the ordinary urinary infections with the exceptions of the *Pseudomonas* and *Streptococcus fecalis*. The *Streptococcus fecalis* is extremely resistant unless the urine is strongly acidified to a hydrogen ion concentration of 5 and below before using sulfathiazole. Of great importance is the effectiveness of the drug in alkaline incrusting infections. For the first time, we are able to save these people from constant misery and progressive renal destruction. When giving small doses, the urinary output must not exceed 1,000 to 1,200 cc. of urine daily.

In acute hematogenous infections, dosages must be sufficient to hold the blood concentration of the drug at 2 to 5 mg. per cent.

The remarkable specificity of the drug is such that if clinical improvement is not noted within three days, the drug is valueless and should be withdrawn. Extensive renal damage, obstruction, and foreign bodies diminish the effectiveness of these drugs as bacteriostatics, just as in the past this has been true of the older less efficient urinary antiseptics.

Intolerance to sulfathiazole should be watched for at all times. If any doubt exists, the drug should be withdrawn. Toxic reactions bear no relation to the amount of drug being administered. They occur just as frequently on  $7\frac{1}{2}$  gr. a day as on 60 gr. daily. These reactions may be puzzling. A good rule is to withdraw the

drug from any patient who develops chills and fever several days after starting sulfathiazole, if no renal tenderness can be demonstrated and the white blood count is 10,000 or below. Photophobia and conjunctivitis may precede the fever and the more common signs, nausea, vomiting, and skin rashes, are familiar to all. Any of these reactions indicate immediate withdrawal of the drug.

The effectiveness of sulfathiazole and related compounds has required us to change our conception completely of the management of urinary infections. The haphazard administration of the drugs cannot be too strongly condemned. However, they will accomplish what was impossible a few years ago, a sterile urine in the presence of severe upper and lower urinary tract obstruction and bacteriostasis and symptomatic improvement in the presence of foreign bodies, stones and incrusting tumors.

The relief of symptoms may lull both clinician and patient into delaying adequate investigation until irreparable damage has taken place as a patient may feel better to have the secondary infection in his tuberculous bladder controlled but his renal tuberculosis may continue unchecked; or the bleeding and incrustations of bladder tumor may be temporarily improved, but the cancer has not been affected. With these new, more effective weapons at our disposal, there never has been a time when the duty of those who assume the responsibility to treat infections of the urinary tract has been clearer.

They must be fully cognizant of the possible paths of invasion and the predisposing factors which precipitate invasion of the urinary tract. They must be able to recognize physiological variation as well as anatomical abnormality in the urinary tract, and they must treat the patient as an individual, if success is to crown their efforts; they must know intimately the details of the problem to be dealt with and the limitations and dangers of the drugs employed.

Someone has said that the reason there are so many chronic urinary infections is because acute infections are so poorly treated. It is not enough to carry the patient past his febrile period to asymptomatic relief, but treatment should be continued until cure has been obtained or all possibilities of cure have been exhausted. If cure results, periodic examinations should be made over an extended period of time to insure its permanence and mitigate against late recurrence. Then and then only, have you discharged your responsibility to your patient.

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# THE DIAGNOSIS OF RENAL TUBERCULOSIS

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MOST urologists are of the opinion that renal tuberculosis is seen less frequently today than in the past two decades. This is due to the reduction in the incidence of pulmonary tuberculosis, as shown in recent data published by the National Tuberculosis Association, the control of the bovine form of infection and the more common use of pasteurized milk. Renal tuberculosis is, I think, more commonly encountered in the larger metropolitan centers and in the Northern and North Central states than in the Southern and Southwestern states.

## HISTORICAL

Since it is only in quite recent times that means have been available for the early recognition of renal tuberculosis, it was inevitable that indications for its treatment should have lagged behind the general march of progress in the field of medicine. And because in its early stages clinical symptoms may be nil, or may differ in no way from those of other common urinary affections, for a long time only advanced cases of renal tuberculosis were recognized, in which the bladder, ureters and kidneys had all begun to show extensive destruction, such as were seen in certain museum specimens. It was not strange that the infection was universally believed to be of an ascending nature, starting in the bladder, where the first symptoms were observed, and supposedly reaching the kidneys little by little over a long period of time. Such changes, moreover, were so complex that the idea of their eradication by nephrectomy was inconceivable.

The French urologist, Tuffier, wrote in 1892: "Surgical intervention in renal tuberculosis should be limited to palliative measures. Retention of pus or the presence of intense pain are the principal grounds

for operative measures." The idea of nephrotomy was accordingly taken up and the procedure carried out in certain severe cases, but it resulted at best in mediocre relief, and at worst in disaster. Albarran was quick to call attention to the persistence of infection and intoxication and to the invariable failure of the fistula to close. Cachexia increased and none of the nephrotomized patients survived more than one and one-half to two years.

All of this was revolutionized with the discovery that the tubercle bacillus primarily invaded the kidney from some other tuberculous focus within the body and had been secondarily passed on to the bladder. Actually, through an error of diagnosis, Peters in 1872 had done the first tuberculous nephrectomy. But it was not until between 1892 and 1900 that nephrectomy was generally employed in renal tuberculosis and at first the results were far from satisfactory, owing to the difficulty of determining the status of the opposite kidney. In 1897, Albarran published an article in which he set forth the merits of the new surgical method, which, with his introduction of ureteral catheterization as a means for the determination of the differential function of the two kidneys, placed the treatment of the tuberculous kidney on an entirely new footing. He showed the advantages and the necessity of early intervention and carried out nephrectomy in cases in which the lesions were so slight as to seem almost latent. The new method was taken up with enthusiasm by the leading surgeons of that time throughout Europe, and in the United States by such men as Kelly, Meyer, Bevan and others. Today early nephrectomy is universally accepted as the only curative surgical treatment in cases in which the opposite kidney is sound.

In the years that have intervened since the introduction of ureteral catheterization, means of diagnosing renal tuberculosis have been multiplied and today it is usually possible to make an early diagnosis on the basis of the history, the clinical findings, the results of cystoscopy, urography, and the finding of the tubercle bacillus in the urine. With an early diagnosis renal tuberculosis has passed into the category of curable diseases.

#### ETIOLOGY

It is now fully established that renal tuberculosis is definitely secondary to some primary focus of tuberculous infection elsewhere in the body. This focus may be a small gland in the mediastinum or mesentery, an incipient apical tuberculosis, a bone lesion too slight to attract attention, or associated with a lesion of the prostate, seminal vesicles or epididymes.

The incidence of associated genital lesions is high. Caulk found co-existing lesions of the prostate, seminal vesicles and epididymes in 75 per cent of his cases of renal tuberculosis. Young found tuberculous epididymitis associated with 26 per cent of his patients suffering with renal tuberculosis and Bumpus and Thompson in studying 606 cases of genital tuberculosis, found 42 per cent associated with renal lesions.

The infection of the kidney is hematogenous in origin in the vast majority of the cases; however, the possibility of a lymphatic invasion in some cases cannot be denied. Thus Hess cites a case in which infection was demonstrably passed by the lymphatic route from a tuberculous focus in the cecum to the right kidney, there being, as is well known, direct communication between the lymphatics of these organs. A third route taken by tuberculous infection is from one kidney to the other by way of the bladder through vesico-ureteral reflux. When the region of the trigone has become infected, changes in the ureteral orifices make it possible for the bacilli that have traveled down one ureter and into the

bladder to enter the opposite ureteral orifice readily and ascend to the kidney.

#### INCIDENCE

Sellaras and von der Becke found in a study of 1,724 patients with urological symptoms fully 16 per cent with renal tuberculosis. Kuster reported renal tuberculosis in 10 per cent of patients dying of tuberculosis. Caulk found tuberculosis responsible for 19 per cent of his nephrectomies while Kronlein showed tuberculosis of the kidney to occur in 28.9 per cent of all surgical operations on the kidney. These figures contrast quite markedly with my findings of four cases of renal tuberculosis in 1,131 consecutive urological examinations.

#### THEORY OF BILATERAL RENAL INVOLVEMENT AT OUTSET

Two principal types of renal tuberculosis exist: (1) A sudden, fulminating, bilateral type, which is part of a general miliary tuberculosis, in which the parenchyma of the kidney is suddenly overwhelmed by multiple emboli of the tubercle bacillus, with death ensuing so swiftly that the diagnosis is usually made at autopsy, and (2) a slow developing, chronic type, which may remain silent for a long time after the blood-borne infection has reached the kidney, and which is amenable to surgical treatment. It is this second type which is under consideration here.

Whether the chronic form of renal tuberculosis in unilateral or bilateral at the outset is still debated among urologists. Hammond stated that it begins in one kidney in 92 per cent of the cases, but that those dying of it have both kidneys involved in 70 per cent of the cases. Hess holds that it has been clinically established that it may remain confined to one kidney for many years. In a study of experimental renal tuberculosis in guinea-pigs, Medlar and Sasano, who observed a striking resemblance of the lesions in these animals to human lesions, found that in 88 per cent of their series the lesions were bilateral.

Cortical lesions were the most common, but medullary lesions were more destructive to kidney tissue. All their guinea-pig lesions were hematogenous. According to Caulk, both kidneys evidently receive an equal share of the tubercle bacilli yet only one becomes diseased at first, while the other, possibly because of local resistance, freedom from allergy, or inherent anatomical integrity, does not share in the infective process until later when bilaterality will almost surely result from infection in the bladder, by ureteral regurgitation of its contents to the sound kidney.

It would appear that the generous blood supply of the kidneys must enable them to overcome a large number of early infections on one or both sides. Chute believed that bilateral infection is frequent, but that this rich vascularity of the renal tissues offers a strong defense which serves them efficiently until some obstructive condition weakens their normal resistance and gives a foothold to the Koch bacillus. Braasch and Sutton reported 2,200 cases of renal tuberculosis observed at the Mayo Clinic during the years 1910 to 1934, and clinical evidence of bilateral involvement was present in 291 cases (13 per cent).

Cabot is of the opinion that the infection is always bilateral at the outset and that the lesion may become surgical in importance in only one kidney in the early course of the disease.

Thomas and his co-workers believe that renal tuberculosis is a local manifestation of a constitutional disease, is practically always hematogenous and may be primarily a bilateral infection. The lesions may be destructive or inflammatory; those that are inflammatory may heal. They believe that healing frequently occurs in initial tuberculous lesions of the kidney; that there is room for the view that the present strains of the tubercle bacilli may be undergoing a change, and that also the resistance of renal tissue to these strains may be undergoing a change, all of which, with improvements in the modern methods of treatment, greatly enhance a favorable prognosis.

#### SYMPTOMATOLOGY

So slow is the progressive invasion of the kidneys by Koch's bacillus that the infection may have been implanted for years before any symptoms arise. The first symptoms are those of cystitis. The patient complains of frequency, especially at night, and suffers with dysuria and urgency; in children incontinence is to be expected and it is sometimes present in adults. If the trigone is involved, the pain will be especially acute at the close of micturition. In most cases lumbar and renal pain supervene and the kidney may become tender on palpation. Occasionally, profuse hematuria is an early symptom—in some cases the first. The urine may be loaded with pus and red blood cells are present microscopically. Loss of weight and general debility are frequent. But none of these symptoms are pathognomonic of renal tuberculosis and it is obvious that the diagnosis cannot be made on these alone. One point, however, must be stressed, namely, that in all cases of cystitis that persist in spite of treatment, the possibility that the patient is suffering with renal tuberculosis should not be overlooked. Berthoin points out that in elderly men the symptoms are so often suggestive of an infected prostatism that this warning is especially important.

A deceptive feature in some of these cases is the occurrence of long remissions free of painful symptoms, sometimes for years and with a relatively clear urine. Bernard and Heitz-Boyer point out that this remission is only clinical; the disease is slowly at work in the dark and that for every cavity that is obliterated a new nodule is forming. According to the patient's general resistance, the progress of the hidden renal tuberculous process will be more or less rapid; and it is now beginning to be recognized by urologists that general constitutional treatment can strongly influence the length of the remissions and hold off the rapidity of the destructive process. Thus Thomas emphasized the rationality of putting a patient to bed and employing a

comprehensive hygienic regimen. He states that repeated instances have been observed in which patients under intensive constitutional treatment for other tuberculous conditions, which at the time precluded any surgical trauma, have experienced marked amelioration of urogenital symptoms. Thus it would appear that there is a constitutional factor behind these alternating remissions and exacerbations of the symptoms of renal tuberculosis; and that the exacerbations, if they cannot be prevented from their inexorable march of destruction, can at least be subject to some control through a better understanding of the factors at work.

#### URINARY FINDINGS

*Urinalysis.* The most important evidence of the presence of renal tuberculosis is furnished by examination of the urine. The earliest sign here is usually the finding of pus cells microscopically which may exist in a sparkling clear urine. Red blood cells are frequently found throughout the entire course of the disease. In the later stages the blood cells may be masked by the pus cells, which are never absent in renal tuberculosis and which may exist in enormous numbers, causing marked turbidity.

Casper states that he has found the Koch bacillus in 80 per cent of cases if the correct staining technic was used. It is not easy to find this bacillus, since there are seldom many of them in the amount of urine available for study. Their number varies, often being greater in the early than in the late stages of the disease. It diminishes when renal bleeding occurs, but Israel points out that they are numerous when bladder tuberculosis is far advanced. The bacilli are not, however, discharged into the urine if the tubercle formation has not yet broken through into the renal pelvis, or if for any reason the diseased kidney or its ureter is shut off from the bladder. Rapid changes in the degree of turbidity may occur as cavities break open or become closed in the kidney.

Caulk utters a warning that the presence of tubercle bacilli alone does not warrant nephrectomy, since the number of these organisms bears no relation to the gravity or extent of the renal lesions. Bacilli, plus microscopic blood, plus pus, are necessary to constitute the picture before any drastic action is carried out.

Albuminuria is a rather constant finding, so constant, indeed, that Wildbolz considered its absence almost a negation of the presence of tuberculosis in the kidney.

As early as 1897, Melchior announced that tuberculous urine is always acid in its reaction. This was confirmed by Suter in 1907 and later by Caulk and many others. This acidity has been widely used as an argument to account for the allegedly constant absence of other infectious organisms from the urine. In view of the general belief that had been given to the idea that the urine by its acidity inhibits the growth of other organisms in renal tuberculosis, Alcorn and Buchtel in 1938 undertook to determine whether this was actually true and found that in 38 (44.7 per cent) of the cases of renal tuberculosis studied, other organisms than the tubercle bacillus were actually found, thus refuting the time honored belief that urinary tuberculosis cannot be associated with other organisms. These findings agree with those of Kretschmer and of Sas and Szold.

#### METHODS OF IDENTIFYING THE TUBERCLE BACILLUS

(a) *Stains.* It has been well said by Marion that the difficulty with the tubercle bacillus is not the recognition of it but the discovery of it in a urine in which it may be practically lost in a morass of pus. These bacilli occur very sparingly in urine, and both experience and patience are required to make the necessary studies.

Only by a special staining method can these tubercle bacilli be brought out on the slides. This is accomplished by the Ziehl-Neelsen (carbol-fuchsin) procedure. Under a proper technic the bacillus, if present, is seen standing out clearly and unmistakably

in red clumps against a background of blue pus cells. Before staining, it may be desirable to digest secondary infecting organisms by the antiformin method, but even so, an almost endless series of slides may have to be examined before any of these elusive bacilli are found.

Hyman and Mann, in a study of the urine from 126 cases of renal tuberculosis, found that the bacterial content of the urine varies considerably at different stages of the disease. If a new focus is opening up, the organisms may appear in veritable showers, which no one could miss; whereas in advanced cases with thick purulent urine and numerous secondary infecting agents, it may be impossible to find them even in smears from an extirpated kidney.

The percentage of positive results from studies of smears varies widely in the reports of different workers. Wildbolz, for example, found the bacilli in 90 per cent of 155 nephrectomies, Casper in 80 per cent and Hyman and Mann in 65 per cent of 102 operative cases.

The smegma bacillus, which also stains red with the Ziehl-Neelsen stain has sometimes been mistaken for the tubercle bacillus; but if proper care is taken in collecting the urine specimen, no confusion should result.

(b) *Guinea-pig Inoculations.* When smears give no decisive results, there remains the more time consuming method of guinea-pig inoculation with the urinary sediment, introduced intraperitoneally, subcutaneously or in the groin. This procedure entails a waiting time of some six weeks which has seemed to some urologists a needless and regrettable waste of time. To others, perhaps the majority, this delay presents no disadvantages in view of the very slow course of the disease. Attempts to shorten the waiting time by various expedients have not been wholly satisfactory, and the method, as developed in 1882, is being used today with a technic that has undergone little modification. All urologists agree that it is a very valuable aid, but admit it is not infallible. As to the per-

centage of error, opinions differ considerably. Thus Barney and Jones reported that they found it 99.5 per cent accurate in 197 proved cases of renal tuberculosis at the Massachusetts General Hospital, only two cases giving negative results. They expressed the view that, when the test is carefully carried out, it is by far the most accurate diagnostic aid available, and that a negative test is accordingly of indisputable value.

According to Casper, who values highly this mode of procedure, there are two possible ways to account for negative results in positive cases: (1) In an early stage of renal tuberculosis, there are periods when no tubercle bacilli, or only very few, are present in the urine, which is therefore incapable of infecting the guinea-pigs. This would be the case if the process had not yet reached either the renal pelvis or the canaliculi. (2) The tuberculous kidney is at times shut off and no tuberculous product reaches the urine. Casper never operates on a tuberculous kidney until guinea-pig inoculation has proved that the opposite kidney excretes a negative urine. He insists also upon two consecutive negative results of such inoculation.

Morse and Braasch have not found guinea-pig inoculation sufficiently reliable to be trusted unless confirmed by uroscopy, cystoscopic data, clinical data and examination of the genitals. Renal tuberculosis should never be diagnosed based on inoculation alone. In eight of a series of forty-five cases of proved renal tuberculosis (17.7 per cent) the guinea-pig findings were negative. In 109 cases of proved tuberculosis of one kidney, with the other thought to be a normal mate to a tuberculous kidney, guinea-pig inoculation was positive in eighteen per cent. When the inoculation made with urine taken directly from the kidney is positive and any of the data mentioned are positive, the diagnosis of renal tuberculosis is evidently correct. But such a diagnosis should never be made on the inoculation without other supporting data.

Comparing the relative advantages of smears and guinea-pig inoculations, Hyman and Mann give preference to the smear as a simpler procedure and one that can be rapidly carried out. They found the guinea-pig inoculations so time consuming as to be impracticable as a routine procedure. In the series of sixty patients submitted to both tests, the diagnosis was in most instances made on a careful study of clinical symptoms, cystoscopy and smear examinations.

In examining the kidneys of the guinea-pig after it has been killed, Medlar and Sasano point out the necessity of making serial sections of both kidneys to avoid overlooking tuberculous lesions that may have developed there. They conclude that negative findings do not rule out tuberculosis. Incidentally, they found no evidence to support the theory of excretion of tubercle bacilli from a normal kidney.

#### CYSTOSCOPIC EXAMINATION

*Bladder Appearance.* The changes observed in the bladder in cases of renal tuberculosis are so characteristic that one who is familiar with them can almost make the diagnosis at a glance. Two types of lesions exist: granulations and ulcerations of the bladder mucosa.

The granulations, which are about the size of the head of a pin, may be single or multiple. In the latter case they may form a cluster or ring around the ureteral orifice, the trigone or the fundus of the bladder. Each is a small pustule of a yellowish color surrounded with a red halo.

The ulcerations, too, fall into two classes, some being slightly elevated with red margins, the others deeper, somewhat more extensive, with their margins notched and eroded and exhibiting a variety of colors. At times they are difficult to distinguish from ordinary ulcerations which may also be present at the same time. If one or both of the ureteral orifices are seen to be rigid and gaping, the picture should immediately suggest tuberculosis. With time the bladder contracts and its capacity diminishes. The

deformities of the ureteral orifices cause a deviation of the trigone which is pulled out of shape by the rigid and contracting ureters. Trigonitis is pronounced and edema develops at the bladder neck.

#### DIFFERENTIAL DETERMINATION OF KIDNEY FUNCTION

In determining what course to pursue in treatment of a tuberculous kidney, it is of the first importance to know the condition of both kidneys as regards function and the amount of infection present in each. By ureteral catheterization we are able to localize the site of the tuberculous process, to know whether tubercle bacilli are present in one, or both, kidneys, to determine the extent to which each kidney is excreting pus and blood cells, and the ability of each kidney to excrete indigocarmine or phenolsulfonphthalein.

In bilateral renal tuberculosis the answers to these tests may save the life or speak the doom of the patient. The question arises as to the criterion on which to base the diagnosis of bilateral renal involvement. We have seen that some surgeons will not remove a kidney if its mate is found to contain a single tubercle bacillus, even though there is no sign of blood or pus, and all functional tests are satisfactory. Hyman and Mann, Braasch and others, point out the doubtful wisdom of considering a kidney tuberculous under such circumstances, when such a decision may spell death for the patient who is denied the benefit of a needed nephrectomy. They remind us that the mere presence of pus in the second kidney does not prove tuberculosis for it may be due to a non-specific infection. The combined presence of the tubercle bacillus, of pus and of blood in the urine of the kidney under consideration would seem to be a minimum requirement for a diagnosis of tuberculosis in that kidney. The bacilli, without pus or blood, in a clear urine, may be simply a contamination picked up by a catheter passing through the bladder or due to reflux. The diagnosis of each kidney



should be made on *all* the data, not a technical failure or one rather arbitrary criterion.

renal parenchyma becomes necrotic in areas producing an irregular dilatation of the pelvis or calices. (Fig. 2.) Generally

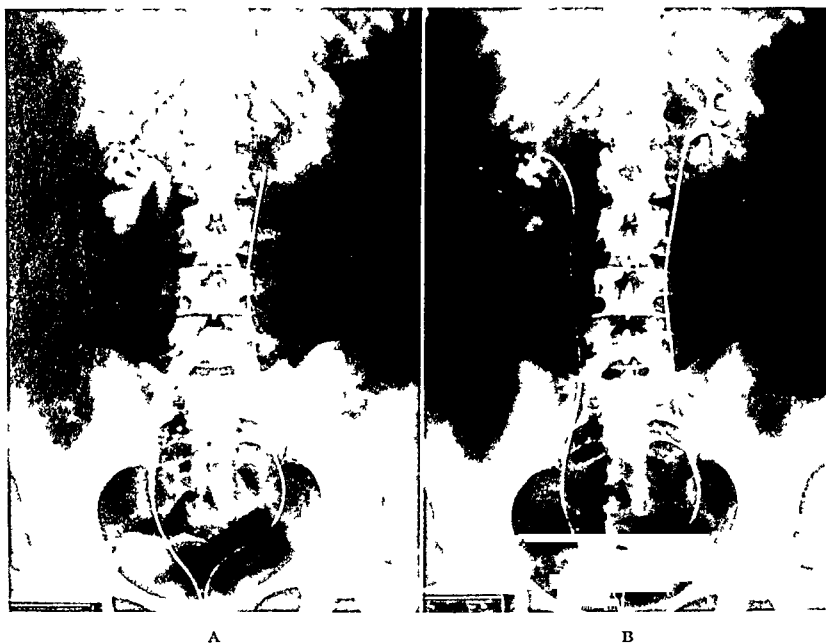


FIG. 1. A, right retrograde pyelogram. Cortical necrosis of the upper and middle calices with irregular dilatation of the pelvis and lower calyx. B, left retrograde pyelogram. Normal pelvis and calices (Urine negative from this kidney.)

#### UROGRAPHY

A small defect in the pyelogram of a patient with an essentially negative bladder may direct the examiners attention to the possibility of a tuberculous infection.

Braasch has most ably described the most important changes caused by tuberculosis in the renal pelvis and ureter as follows:

1. *Areas of Cortical Necrosis in the Kidney.* This defect will usually be seen in the outline of one or more of the calices and the appearance is that of irregular dilatation with uneven "moth-eaten" borders. (Fig. 1A and B.)

The apices of the calices are more likely to show this deformity with occasionally detached areas in the adjacent renal parenchyma. Unless the pathologic process involves the renal papilla no deformity characteristic of the disease will be obtained in the pyelogram.

2. *Irregular Dilatation of the Renal Pelvis.* As the inflammatory process continues the

the renal pelvis is not tremendously enlarged unless stricture has developed in the ureter and produced some degree of hydronephrosis.

Braasch further points out that when the process is confined largely to the cortex, the pelvis may become contracted in a manner similar to certain forms of atrophic pyelonephritis.

3. *Stricture of the Ureter.* The infection produces areas of ulceration in the ureter which in time become cicatricial and result in a definite stricture. These areas of constriction are usually multiple and appear urographically as alternating areas of constriction and dilatation.

Crenshaw found 7.1 per cent of the cases of renal tuberculosis under his observation to have calcification and found this condition more common in men. The calcification is cortical, irregular and may be miliary. (Fig. 3.)

In considering a pyeloureterogram one may be confused by certain deformities

produced by pyelonephritis and artifacts. In pyelonephritis the dilatation is more commonly uniform in its involvement.



FIG. 2. Right retrograde pyelogram. Irregular dilatation of the pelvis, upper and middle calices.



FIG. 3. K.U.B. Triangular area of calcification in the mid-cortical portion of the left kidney. Irregular areas of cortical calcification in left kidney. (Acid fast organisms recovered from each kidney.)

Artifacts may be produced by overdistention and incomplete filling of the renal pelvis with the pyelographic medium. The extravasation distal to the tips of the calices resulting from overdistention, when associated with pyelonephritis, may appear similar to the deformity produced by cortical necrosis as a result of tuberculosis. Incomplete filling of the pyelogram may likewise result in confusion in the interpretation.

Excretory urograms, as a rule, do not demonstrate the early defects characteristic of renal tuberculosis. However, the excretory urogram is valuable in following the course of the disease once the diagnosis has been established and it gives additional information as to the function of the two kidneys. Evidence of gross disproportion in the involvement of the two kidneys is clearly demonstrated by this method.

#### SUMMARY

The incidence of renal tuberculosis is today less than in the past two decades due

to the reduction in the incidence of other forms of tuberculosis. It has been fully established that renal tuberculosis is sec-

ondary to tuberculous infection elsewhere in the body and that the organism is carried to the kidneys by the blood stream in most instances.

The question of bilateral involvement of both kidneys, at the outset, is not fully decided; however, the work of Medlar and Sasana demonstrated 88 per cent of their guinea-pigs to have bilateral renal lesions. Clinically, Braasch and Sutton were only able to demonstrate 291 cases (13 per cent) of bilateral involvement in a total of 2,200 cases of renal tuberculosis studied.

The symptoms vary from nil to those of a very painful cystitis with later pain and tenderness in the kidney region. Occasionally, hematuria may be the first symptom. A deceptive feature in some cases is the occurrence of long remissions free of painful symptoms. No symptom or train of symptoms is pathognomonic of renal tuberculosis.

The urinary findings give the most important evidence of the presence of renal

tuberculosis. Pus cells are regularly found and red blood cells and albumin are usually present throughout the entire course of the disease. The acid fast bacillus is found on staining the centrifuged urinary sediment in a large percentage of the cases and guinea-pig inoculations are to be employed when the smears give no decisive results.

The cystoscopic appearance of the bladder is quite characteristic. Two types of lesions exist: granulations and ulceration. The function of each kidney is to be determined as well as the microscopic contents in the urine of each kidney. The presence of a few organisms in the urine from one kidney in the absence of pus cells, red blood cells and albumin may represent a contamination in passing the ureteral catheter through an infected bladder.

The pyelogram is of great value. A small defect may first direct the examiner's attention to the possibility of a tuberculous infection. Cortical necrosis is demonstrated when the lesion involves the renal papilla. The excretory urogram usually does not demonstrate early defects as well as the retrograde pyelogram. However, the excretory urogram is valuable in following the course of the disease and in demonstrating disproportion in the involvement of the kidneys.

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# TUMORS OF THE KIDNEY\*

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THAT individual presenting himself for urologic care which subsequently unfolds the probability of renal tumor rarely does so because of an awareness of his disease but because of a symptom (or group of symptoms) which to him is sufficiently divergent from his customary health to arouse his desire for medical sanctuary. The degree and duration of divergence necessary to establish this desire, coupled with the acumen of the medical advice received prior to urologic examination, frequently but not always determine at what phase in its biologic cycle the tumor is to be attacked. While it is possible that the public has been unwittingly educated into expecting too great a panacea from early diagnosis, one may scarcely deny that the eventual outcome is influenced in a large degree by the distance from its inception at which the tumor is treated. It thus becomes the obligation of the profession at large to suspect the possibility and direct the proper investigation before all classical symptoms and findings have developed, as well as the duty of the urologist to perfect the technic of early diagnosis and the improvement of treatment leading to a future of more hope than the gloom of the past.

While in practice the problem is that of synthesizing the component parts of history, physical examination, laboratory and roentgen findings into diagnosis and treatment, it is, *per se*, in a written discussion of the subject, necessary to start with acceptance of the fact, a tumor, and thence, in the opposite direction, by analysis to develop those various components. The absence of any pathognomonic picture, at least until late in the life of the disease, does

not facilitate the problem. It is further unfortunate that our knowledge of pathological conditions and treatment is far from the complete agreement of the recognized authorities whose honest differences of opinion are greater on these two aspects than in the problems pertaining to symptoms, findings or diagnosis. It is our undertaking at present to present a constructive clinical review of renal tumors, but it must be admitted with any candor at all that even the most casual survey of the literature is bound to reveal certain controversial points relating to pathological conditions (including classification) and treatment. Happy is he who could maintain a view of renal tumors thoroughly harmonious in all aspects with all recognized authorities. If one wishes to enter the controversy, he should repair to the special articles in the literature rather than to standard texts.

It is not in our domain to consider here cysts of the kidney, whether solitary or multiple, nor cyst-like enlargement due to hydronephrosis or pyonephrosis. They are not in the category of new growths, nor is congenital polycystic disease of the kidneys which, though it may not become patent till adult life, falls more customarily under the heading of congenital anomalies.

## EMBRYOMA

There are six comprehensive contemporary American textbooks of urology. Half of these present a classification on the first page of the chapter on renal tumors, the others implying one by discussion of the subject under topical headings or including it later in the chapter. For the most part those tumors of the kidney occurring in the first decade of life receive

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separate consideration from those of mature years. These tumors are not *frequently* encountered outside of a children's hospital or a large medical center. It is not our intent to include their comprehensive discussion. They do, however, constitute the most frequently encountered malignant abdominal tumor of childhood. The embryoma, or tumor of Wilms, reveals itself usually by the development of a large abdominal mass in the renal area. Hematuria is not an early symptom. Pain and cachexia may or may not be present. Embryoma should be suspected until excluded in every child with a solid mass in the renal fossa. Hypertension has been noted by Koons<sup>5</sup> in a girl of seven years, and relieved by nephrectomy. The patient died (since the publication of his paper) of an hepatic metastasis.\* Metastasis occurs after the tumor has obtained considerable size. Diagnosis rests upon detection of the mass and pyelography. Abdominal palpation should be restricted and not indiscriminately repeated because of the danger of metastasis therefrom.<sup>7</sup> Urinalysis and other routine laboratory analyses will probably be of little aid.

Excretory urography may, under very rare circumstances, obviate further urologic study but it is probably true that no nephrectomy should ever be performed on child or adult *solely* on the basis of findings thereby derived. Retrograde studies are necessary to confirm the presence, condition and function of the other kidney before sacrifice of the condemned one, as well as for diagnostic purposes. On the other hand, anteroposterior retrograde pyelographic study alone is inadequate if not positively diagnostic and should be coupled with a lateral pyelogram as well.

Treatment, insofar as there is agreement, is first preoperative irradiation, and second, nephrectomy (if metastases are not present), followed by postoperative irradiation. Diagnosis is confirmed by gross and histologic examination of the tumor, which will reveal cells originating from types of

more than one germinal layer. There is a general trend in favor of the transperitoneal route if the tumor is of large size. This affords better exposure as well as an opportunity to ligate the pedicle before the mass is traumatized incidental to its dissection. The capsule and perirenal fat should be removed intact with the mass so as to include undemonstrable extension and lymph-nodes. The prognosis is almost universally recognized to be bad, death ensuing from six months to two years after operation as a rule.

It is well here, however, to call especial attention to the report of Ladd<sup>7</sup> who gives the characteristics of an embryoma as follows: variegated histology, rapid growth after a period of slow activity, hemorrhage and necrosis perhaps leading to capsular rupture, possible invasion of pelvis or vein, metastases after attaining large size, and frequency of local recurrence. Ladd does not advise routine retrograde catheterization because of the delay involved, nor does he favor preoperative irradiation because of its failure to kill the entire tumor. He raises the question as to whether the latter prevents early dissemination. He favors immediate transperitoneal nephrectomy. His operative mortality is 7 per cent, and of forty-five patients he reports fourteen alive, eleven of whom are probably cured one and one-half to nineteen and one-half years postoperatively. We have once observed ill effects from irradiation on the good kidney. Examination revealed no evidence of metastases or renal failure. After partial completion of irradiation the left kidney decreased 50 per cent in size. Completion of irradiation resulted in no further decrease but was accompanied by beginning evidence of nitrogen retention and renal failure. In three months autopsy showed a well walled-off left kidney whose histology was of embryonal type. The right kidney was contracted, sclerotic and showed abnormal fibrosis. There were no metastases. Our suspicions could hardly fail to be roused as to a possible relationship between x-ray therapy and au-

\* Personal communication.

topsy findings. Priestley<sup>11</sup> uses preoperative irradiation, nephrectomy and postoperative irradiation over thorax, renal area and abdomen. Of thirty-seven patients with embryomas he reports 33 per cent alive more than three years and 9 per cent more than ten years after operation.

#### PARENCHYMAL TUMORS OF ADULT LIFE

There is no sufficiently characteristic symptom complex of renal tumors of adult life to draw a typical picture. It is rather a partial disclosure of the whole which should constantly be in the mind of the physician. Rarely is such a tumor detected as a result of an accidental, suggestive finding in the course of a routine examination. More often it is because of complaint of the patient due to a symptom originating from a change in the size or position of the kidney, from an abnormality created in the drainage system of the kidney or from an unusual appearance of the urine. In a few instances symptoms have been reported developing from metastases while the home growth was too small to focus any attention. If we anticipate the classical picture of mass, pain and hematuria, we may have to wait a long time in the life of the disease, or be misled (as we recently were when we exposed a polycystic kidney) by some other finding.

#### UNUSUAL TUMORS

Before entering a detailed discussion of the problem we must limit and classify it. Clinically, benign tumors are so rare that we must forego their review. We have seen a benign adenoma incidentally reported by the pathologist in examining a kidney removed because of hydronephrosis. In another instance a calculous pyonephrosis incidentally showed so-called benign papillomatosis of the renal pelvis. The patient is alive and well nine years later. Non-epithelial tumors, including those of vascular origin, are also rare. Metastatic tumors from elsewhere which situate themselves in the kidney are also rare. Abeshouse and Goldstein<sup>1</sup> found that carcinoma in this

connection is five times as frequent as sarcoma; but *relatively* speaking, because of the higher incidence of the former as a primary lesion, sarcoma is twice as common as carcinoma. The kidney is never the solitary site of metastasis. The other kidney is most frequently the original focus. Once we observed such an instance. A highly malignant "adenocarcinoma of renal epithelium" of the left kidney was thought by the pathologist to have metastasized to the right kidney as well as elsewhere (autopsy). In another, a carcinoma of the bladder was found to have involved the right kidney. In a third, a similar primary tumor metastasized to the right suprarenal gland, and at the time of autopsy appeared to be invading the adjacent kidney by extension. Two different primary types of tumor in the same kidney are probably the rarest combination of all.

#### TUMORS OF FREQUENT INCIDENCE

We are all indebted to Hertzler for the statement that solid tumors of the kidney represent  $\frac{1}{2}$  per cent of all tumors. They are usually malignant though the degree may be one of variation. We must recognize two gross types, namely, those arising in the parenchyma and those in the renal pelvis, with subdivisions of each. It is in the subdivisions that differences of opinion arise.

*Classification:* The most frequent tumor of the adult kidney is the hypernephroma. Grawitz<sup>3</sup> believed they developed from adrenal cell rests. Sudeck and Stoerk<sup>3</sup> thought they were adenomas arising in the kidney tissue. Ewing<sup>3</sup> and most contemporary authorities now believe that the majority of malignant epithelial parenchymal tumors are true carcinomas and not derived from adrenal tissue rests. The term hypernephroma, however, is one of tenacious clinical tradition and cannot be shaken by our present day knowledge, regardless of what school we follow. We find that there is about an equally divided tendency of current authors to refer to epithelial malignant parenchymal tumors

as carcinoma or adenocarcinoma on the one hand, and on the other, to recognize the hypernephroma (of indeterminate origin) as an encapsulated, slowly progressing tumor of a lesser degree of malignancy, and the adenocarcinoma as a wildly growing, infiltrating, highly malignant tumor. The first mentioned school subdivides carcinoma into three groups: the papillary adenocarcinoma, the alveolar adenocarcinoma and the malignant papillary cystadenoma. Hypernephroma is more or less encapsulated and apt to lie at one pole of the kidney. On section it may have yellowish streaks and show evidence of hemorrhage, necrosis or cyst formation. The adenocarcinoma is gray or whitish, not encapsulated and fails to reveal necrosis or hemorrhage.

Kozoll and Kirshbaum<sup>6</sup> use the terms, benign or malignant hypernephroma, both of which are yellow and vascular, with a central fibrous core and a cellular cortical area with histologic structures similar to the fascicular zone of the adrenal cortex. The benign ones are small, well encapsulated, produce no deformity, do not metastasize, and present no diagnostic clinical features, always being discovered at autopsy. These they call the benign hypernephroma or hypernephroid adenoma. The malignant or hypernephroid carcinoma are grossly malignant, larger and run a clinically malignant course. In 12,885 consecutive autopsies they found thirty-three of the former and forty-four of the latter. In some which were histologically benign, distant metastases were found. Hence they studied only autopsy material to verify the presence or absence of metastases as an aid to establish criteria of benignity or malignancy. In either instance males predominated 4 to 1 and whites to blacks 4 to 1. Most of their patients representing malignant cases were unoperated upon because they presented themselves too late. Only six of the forty-four died without metastases, the lungs being the most frequent and the bones the least frequent sites. Only five lived over one

year. Six of the malignant ones were of the transitional type, grossly benign but invading the capsule and parenchyma. It is unfortunate that it is clinically impossible to adopt the biologic methods of study of Lucké<sup>8</sup> to which the reader is urged to refer. The fact remains, however, that while the pathologist may discover these relatively benign epithelial parenchymal tumors, in practice the life cycle of the growth has usually advanced beyond this point. We have observed it only twice and that at autopsy. Both were prostatics whose autopsy findings revealed hitherto unsuspected hypernephroma which were in no way related to the cause of death.

*Clinical Aspects.* We have observed in our group (Hamer, Mertz and author) thirty-five patients with malignant tumors of the kidney since 1928. None were seen solely by the author. All were private patients with three exceptions included for special interest. Five of these will be discussed later under the subject of renal pelvic tumors. All of these diagnoses were verified by operation, exploration with biopsy or autopsy. Of the thirty parenchymal tumors two proposed nephrectomies terminated in unsuccessful exploration. One of these was verified later at autopsy. The other was verified by biopsy due to inadvertent removal of a piece of tumor from the capsular region. The former lived eight years after unsuccessful exploration. He received postoperative irradiation. Autopsy revealed adenocarcinoma. The latter was lost to study. Hers was a hypernephroma. Twenty-four of the thirty parenchymal tumors were hypernephroma, four were adenocarcinoma, one was a sarcoma and one a metastatic tumor from the bladder which was unsuspected.

*Symptoms.* The patient will probably be a white man between forty and sixty-five years of age. He may complain of any or all of the common symptoms. Pain is at times of a dull character, located in the costovertebral angle or upper abdomen, perhaps due to capsular tension. Gillies<sup>1</sup> found that fifteen of seventeen such in-

stances were accompanied by a palpable mass. Severe pain or colic is less frequent and is due to an interference with the drainage of urine from the pelvis or ureter. This may be the result of a mechanical pressure effect or, more likely, to the passage of a clot. Pain due to metastases will be predicated upon the location of the latter. Pain is not a diagnostic symptom in itself.

Hematuria frequently is present but not always. Its absence does not exclude the disease. It may be macroscopic or microscopic. In the latter event it will of course be the physician's discovery. The number of urinalyses terminating without microscopic examination continues to be appalling and is due to apathy rather than ignorance. Worse than this, even in the year 1941, emphasis on the importance of gross hematuria still continues to be a missionary obligation. Of all aberrations from normal bodily functions gross hematuria would seem to be as striking and dramatic as any. Whatever its cause it is almost always self limited, in its initial phases at least. For the patient it is perhaps natural to grasp at the hope of *vis naturae medicatrix*; for the physician it never should be. Because of this early self limitation it, therefore, follows that hematuria will stop because of or in spite of whatever medication is tried. It always demands anatomic investigation as to its origin. *Then* let one use what nostrum he will as long as it does not delay proper treatment. In the absence of acute gonorrhea, nephritis or some other obvious and certain medical cause, one subsided attack of gross hematuria always remains as important an indication for special investigation as continuous bleeding. Otherwise we shall continue to see such horrible examples as gross hematuria of sixteen years' duration due to neoplasm of the urinary tract on the assumption of Bright's disease. With hypernephroma, hematuria occurs as a rule from hyperemia or when the tumor communicates with the pelvis or a calyx. It is not as profound as in renal pelvic tumors.

Pyuria occurs in the face of secondary infection.

The tumor is palpable earlier when the growth is in the lower pole. Anterior palpation is insufficient. A hand should be placed in the loin and another on the anterior wall with gradual but deep pressure during several respiratory cycles. Unless the growth has become fixed it will move with respiration and be ballottable. It may be smooth or bosselated. If bilateral the thought would be polycystic disease. In embryoma, the patient or his mother will mention the tumor. In hypernephroma the responsibility is more apt to be up to the physician to find it, though not always.

Anemia is more often due to toxemia than actual loss of blood. Fever is an occasional finding. Hypertension, in the light of recent knowledge of its relation to the kidney, is interesting but the causal relationship unsettled. We have not observed its permanent reduction following nephrectomy. Koons, as previously mentioned, has, and this to date remains the only example in Page's clinic. Spontaneous perirenal hemorrhage is rare and still more rarely diagnosed unless encountered more than once by the same physician.<sup>14</sup>

*Preoperative diagnosis* ultimately rests on urography. Nichols<sup>10</sup> believes that, although more difficult to interpret, excretory urograms are of great value. If used routinely on all admissions, it would doubtless detect some renal tumors which would otherwise escape. Used exclusively on suspected cases our fear would be for the converse. Waters<sup>12</sup> does not advise it. Certain it is that unless the so-called negative excretory urogram is technically perfect (i.e., well filled and well visualized), it should be verified by a retrograde pyelogram before the uncertain case is freed of its suspicion. It is also frequently essential to know more about the other kidney (presence, function and freedom from infection or other defect) than excretory urography may tell. The original roentgenogram should be as free from gas as possible to delineate clearly the renal out-



line. In hypernephroma this might be enlarged or irregular. Braasch<sup>13</sup> has called our attention to occasional findings of calcification which he considers a good omen.

Cystoscopic examination may reveal the side from which the bleeding occurred. Blood, however, in ureteral specimens of urine is of no special diagnostic import (trauma). Special examination also should give us comforting data previously mentioned about the other kidney. As to the pyelogram itself the frequently quoted term "filling defect" requires some explanation. This condition is present in classical examples in tumors of the renal pelvis and clot or nonopaque stone in the pelvis. In the case of hypernephroma, if the tumor has invaded the pelvis or if by pressure it has occluded a calyx or infundibulum, the "filling defect" will be there. In other events we may have rather a bizzare type of pelvis characterized by distortion or displacement. The other pelvis should be normal. Instances of doubt may be clarified by the addition of a lateral pyelogram as Mertz<sup>8a</sup> has clearly demonstrated. Gillies<sup>4</sup> has observed the retrograde pyelogram to show as follows: Cortical elongation and compression in 60 per cent; pelvis and calyx pushed to one side; pelvic invasion uncommon; complete obliteration of pelvic and cortical landmarks in 25 per cent; elongation of calyces with no compression but with dilation in  $7\frac{1}{2}$  per cent; normal pyelograms in 0 per cent. In differential diagnosis our own experience has revealed our shortcomings must make us most alert to rule out polycystic kidney, renal tuberculosis, retained clot in the pelvis and extrarenal retroperitoneal tumor with possible renal invasion.

*Treatment* again leads us into some controversial issues. Barringer<sup>2</sup> has stated that from his own cases irradiation of small doses over a long period gives better results than irradiation followed by operation. Munger<sup>9</sup> favors ultra short wave preoperative irradiation, transperitoneal nephrectomy and limited postoperative irradiation.

Waters<sup>12</sup> finds that over 90 per cent of cortical tumors are radiosensitive, exclusive of papillary cystadenoma (and of course papillary carcinoma of the pelvis). Nephrectomy should follow in two months. Munger does not delay over a fortnight. Braasch believes that irradiation may not reduce the size of the tumor and may increase its fixation and, therefore, is not always of help. Priestley<sup>11</sup> advises preoperative irradiation of the very large tumors to facilitate nephrectomy. He uses the lumbar approach except in very large tumors. Our own experience with irradiation has been limited. We have used it for recurrences which it may have delayed because one such patient was known to be alive eight years and the other three years after operation. An inoperable patient (adenocarcinoma) whom we explored received postoperative irradiation, and again seven years later, shortly after which he died. We know of another instance, however, in which unsuccessful exploration was not followed by irradiation but life was the same duration.

It is almost universally conceded that operation is essential. The present trend favors the transperitoneal approach for reasons mentioned in discussion of embryoma. Pre- or postoperative transfusion may be needed. Contraindications to operation are fixation, metastases, age, cachexia and infection.<sup>13</sup> The other kidney must of course be able to sustain life. Metastases from hypernephromas, though late in the cycle of the disease, are notoriously frequent and generally contraindicate operation. Metastases are chiefly to the lungs, liver and bones. Hypernephroma causes osteolytic osseous metastases and is one of the four most frequent tumors causing bony metastasis (prostate, thyroid and breast). Barney has reported a patient apparently cured by nephrectomy and lobectomy for pulmonary metastasis.

*Prognosis* depends upon the promptness of diagnosis after onset of the disease, on the size of the tumor, on metastasis, on fixation of the tumor, on histogenesis and

on other factors associated with the general condition of the patient. Some believe that the gradation of the degree of malignancy of the tumor has paramount bearing on prognosis (Priestley, Broders, Braasch, et al.) while others do not. Our own experience has been that, with a few gross exceptions, there is relationship. Six and two-tenths per cent of sixty-four patients reported by Waters lived five years without demonstrable recurrence or metastasis. Braasch<sup>13</sup> reports 42 per cent alive over five years after nephrectomy. With explored but unremoved kidneys, 17 per cent were alive for a similar period. Priestley<sup>11</sup> finds the greatest mortality in the first three years after operation. After this, those who succumb do so according to mortality figures of the general population of a similar age. Seventy-three per cent of the patients in his report with grade 1 adenocarcinoma of the renal parenchyma were alive three or more years after operation, 22 per cent with grade 4; 47 per cent with grade 1 were alive ten years or more and 3.2 per cent with grade 4. Forty-six per cent of his patients reported with tumors weighing less than 500 Gm. lived five years or more and 24 per cent with tumors weighing over 1,000 Gm. For more extended study of his very informing report one should consult his article listed in the bibliography.

Of our own twenty-four patients with hypernephromas two may be excluded because of their incidental autopsy finding with death from another cause. Of the remaining twenty-two one was inoperable but explored, three were operated upon elsewhere and showed evidence of recurrence. Of the remaining eighteen we know of five deaths (two months, two, three, five and ten years postoperatively). One of those who died had a spontaneous pathologic fracture, the only such instance we have observed. Only two were due directly to the tumor (local recurrences and metastasis). Of the eighteen, there were four known recurrences (three still alive). Six others are known to be alive and well; one

1 year after operation (and she had a tumor thrombosis in the renal vein), one four years, three six years and one ten years. Five were poorly followed but two of these were known to be alive and well one year after operation. Benign hypertrophy of the prostate was the most frequently encountered, associated but unrelated disease.

Not included above is one patient with a sarcoma alive one year after operation. Four of our patients have had adenocarcinoma. One metastasized to the other kidney as revealed by autopsy (patient not operated upon). Two were operated upon, one of whom had an alveolar adenocarcinoma of the parenchyma associated with calculus. The other had ascites nine years after operation, probably due to recurrence. He was lost sight of before death. The fourth had an unsuccessful exploration and died eight years later.

Our own results with parenchymal epithelial tumors of the kidney would thus lead us to conclude that the adenocarcinoma is more malignant than the so-called hypernephroma and apt to be more inoperable. Preoperative differentiation was not made. Cortical tumor has not been encountered by us in enormous size except once in a private patient and, therefore, transperitoneal removal has not been employed nor has preoperative irradiation been routinely necessary in order to make the tumor removable. Operative death in the hospital was not encountered in our small series of hypernephromas which would lead us to conclude, probably erroneously, that mortality is no greater than from nephrectomy for other causes. Our deaths will begin within two months after operation. Recurrence and metastasis are not uncommon but the incidence of bony metastasis was low.

#### RENAL PELVIC TUMORS

Epithelial tumors of the renal pelvis are thought to be rather infrequent, comprising from 3 to 20 per cent of all renal neoplasms. Gillies<sup>4</sup> found them in 10 per cent of his series. We have noted them in five of

thirty-five patients with some sort of renal neoplasm. This is considerably higher than the average which is generally stated from 5 to 7 per cent. We have found three-fifths to be of the papillary type which conforms to most reports. Lowsley states that men are afflicted with papillary tumors more often than women, which has been our experience. Gillies found no sex difference. Four of his five patients were seventy or over. Three-fifths of our patients also were over seventy. We have observed only one so-called benign pelvic tumor (papillomatosis) but have not included it in this series because the patient was operated upon for stone and the tumor was an incidental finding.

The nonpapillary flat types (squamous cell) are reputed to develop more often than the papillary types in the presence of stone, leukoplakia or chronic inflammation. Nonepithelial types are rare. Renal pelvic tumors associated with cortical tumors are still more so. Balch, of Indianapolis, has encountered one instance of papillary carcinoma of the pelvis in a kidney harboring a hypernephroma. Pelvic tumors may invade the parenchyma. They cause hydronephrosis more often than cortical tumors. They spread via the lymphatics. Metastases also spread to the lungs, liver, adrenal and bone (Lowsley). The papillary type is prone to occur coincidentally in the ureter and around the ureteral orifice in the bladder, not, according to Keyes, because of implants but because of the same factor which prompts the origin of the growth in the pelvis. The prognosis is absolutely bad in the nonpapillary type and better in the latter because it metastasizes later.

The signs of the disease are similar to those of cortical tumors but vary in certain respects. Hematuria is more intermittent and severe. Clots are frequent. Pain is due to obstruction of the pelvis or the passage of clots. Tumor mass is less frequent. Tissue may be found in the urine and loss of weight and anemia are not uncommon.

*Preoperative diagnosis* is difficult in differ-

entiating from cortical tumors and rests on history, physical and special urologic examinations. The last mentioned consists of (1) urinalysis which may reveal tissue cells; (2) cystoscopic examination which may show bladder involvement and which is apt to provoke traumatic bleeding when the pelvis is catheterized and (3) pyelography which discloses either hydronephrosis, distortion, true filling defect or a combination of all. Clots and nonopaque calculus must be excluded in differentiation of the pyelogram.

*Treatment* consists of nephroureterectomy unless contraindications (see hypernephroma) are present. The tumor is radioresistant and irradiation is, therefore, not as much avail. The kidney and upper ureter may be removed by the lumbar route and the lower ureter together with a sufficient cuff of bladder wall through an anterior extraperitoneal incision.

*Prognosis* of pelvic tumors is not good due to the highly malignant type of the tumor, to the possible presence of perirenal extension and to metastases. The fact that these tumors occur at an older age of life than the cortical tumors does not enhance the patient's operative risk. Braasch states the average length of life as less than two years. The papillary type offers better prognosis than the flat variety, no five-year cures of the latter being on record (Lowsley). Priestley reports 45 per cent of patients with pelvic tumors alive three or more years after operation, 35 per cent for five or more years and 10 per cent for ten or more years.

Our own contact with renal pelvic tumors follows: Correct diagnosis was established before pathologic diagnosis in two of five patients. A woman of seventy-seven years, complaining of pain in the left renal fossa, had a pyelographic diagnosis of hypernephroma. Subsequently, squamous cell carcinoma was found but our records do not make clear whether this was based on autopsy or operation. She died within several months of the first diagnosis, hav-

ing been treated by irradiation before correct diagnosis was made.

A man, sixty-two, had a preoperative diagnosis of calculous pyonephrosis. His complaints were hematuria and gastrointestinal upsets. Findings at operation showed duplication of the pelvis as far as the ureteropelvic juncture, with a stone at that point, and pyonephrosis. In the course of nephrectomy a tumor of the lower pelvis and lower pole of the kidney was found. The tumor had extended into the cortex and the perirenal fat, as much of which as possible was removed. Pathologic diagnosis pertaining to the neoplasm revealed a transitional cell carcinoma of the pelvis with invasion and penetration of the kidney. Four months later the patient had "resistance in the left abdomen" but no mass. He died five months after operation of recurrence or incomplete removal. Irradiation was given after the patient returned home, ending two months before death. He improved clinically during the period.

A third patient was a man, fifty-six, with hematuria whose preoperative diagnosis was hypernephroma. He had a pathologic diagnosis of grade 2 papillary carcinoma and a solitary cyst. However, we had treated him ten months thinking the bleeding to be from the prostatic hypertrophy before renal tumor was found. Urologic examination five months after operation showed no bladder extension. He received preoperative irradiation, largely because hypernephroma was suspected. He is now well six months after operation without evidence of recurrence or metastasis.

A colored man of seventy-four complained of hematuria. Small benign hypertrophy of the prostate was found which bled on trauma and was resected. Hematuria continued so an upper tract investigation was made in one month. Left duplication of pelvis and ureter was found; hematuria was on the right. Hydronephrosis with filling defect prompted a preoperative diagnosis of papillary carcinoma of the pelvis. Lumbar nephrectomy was done, the pelvis torn accidentally and the incision

contaminated with cauliflower-like tumor. There was no evidence of perirenal involvement. The incision was filled with tincture of merthiolate and sponged thoroughly before and after. Intensive postoperative irradiation was given. Pathologic diagnosis was papillary squamous cell epithelioma of the pelvis, hydronephrosis, ureteritis cystica, and fibroma of the medulla. No recurrence has developed to date (twenty months after operation). The upper ureter was removed with the kidney and showed no neoplasm. Complete ureterectomy was not done because it was believed at the time that the patient would not stand it.

The last patient was a woman, aged seventy, who had been treated seven years for right pyelitis. Hematuria then developed and there was a change in the pyelographic findings with hydronephrosis and filling defect. Lumbar nephrectomy was performed with a diagnosis of tumor of the pelvis. The pathologic report showed malignant carcinoma of the pelvis with papillary formation, hydronephrosis and bifid pelvis. Cardiorenal death followed in ten years. Autopsy showed pyelonephritis of the remaining kidney and multiple vesical diverticula with stones, no recurrence and no metastasis.

In our four operative cases mistaken diagnosis in two did not suggest ureterectomy. One of these was in too poor a condition to have tolerated it if contemplated, and would have died at any rate because of perirenal extension, even if ureterectomy had been done. The other has no recurrence but is only six months post-operative. In the two patients with correct preoperative diagnosis the age and feeble condition restrained us from ureterectomy. One died ten years after nephrectomy without recurrence and the other is alive twenty months after operation and in good health. We do not mean to imply that ureteronephrectomy is not warranted but rather that we happen to have been fortunate. None of the patients showed ureteral extension histologically. Pelvic

infection was prominent in all four operative cases. There is an obvious lesson from two of the three male operative cases, viz., hematuria assumed to be due to benign hypertrophy of the prostate, which does not stop promptly with proper treatment, should at once indicate investigation of the upper urinary tract. Hematuria without a palpable kidney was constant in all four patients. With elderly patients of long standing upper tract infection, periodic pyelography should be performed to detect the onset of any new development such as carcinoma of the pelvis.

Extrarenal retroperitoneal tumors<sup>14</sup> are a chapter in themselves and will not be discussed here. They may, however, be confusing from point of view of differential diagnosis and should be distinguished from cortical or pelvic tumors.

#### SUMMARY

The difficulties of the various problems of renal neoplasms are discussed. Embryonal tumors of childhood are touched upon. Rare parenchymal tumors are mentioned by name only. Most frequently encountered parenchymal tumors ("hypernephroma" and adenocarcinoma) are discussed with minimal pathologic consideration, and at some length clinically from point of view of symptoms, diagnosis, treatment (operation and irradiation), prognosis, and our own experiences (including blunders) with thirty patients. Tumors of the renal pelvis are discussed in a similar manner with relatively more emphasis on our own findings in five patients.

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# CANCER OF THE BLADDER

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THIS paper is primarily intended to include some of the pertinent points regarding the diagnosis of cancer of the urinary bladder. The satisfactory treatment of vesical malignancies, not unlike the majority of cancer involving other parts of the body, depends for the most part upon early diagnosis and prompt institution of adequate therapy.

The writers believe that it is of vital importance to adhere to a rigid schema and preoperative program for studying each suspected case. Insufficient information is acquired from cystoscopic examination alone. Emphasis must be placed on the following points: (1) history of the case, (2) physical examination, (3) urinalysis, (4) classification, (5) cystoscopy and biopsy, (6) cystography and urography, and (7) differential diagnosis.

*History.* A careful history is of considerable importance because the duration of symptoms and the severity of symptoms may give one an index as to the degree of malignancy. This is shown by the fact that painless hematuria of an intermittent type is often the only complaint and it may have been noticed and ignored by the patient for a great many years. We know of one case in which the patient had gross hematuria eighteen years prior to seeking medical counsel. At operation a large papillary carcinoma with infiltration of the bladder wall was found. Had this patient sought advice with the advent of his initial hematuria it is probable that a thorough transurethral destruction of the tumor may have resulted in a permanent cure.

From the histories of patients with bladder neoplasm it will be learned that in a very high percentage of the cases the initial symptom was gross hematuria. In reviewing our material for study which consists of 211 cases of malignancy of the

bladder examined and treated at the Mercy and Presbyterian Hospitals in Pittsburgh, we learned that, in 146 or 67.3 per cent, gross hematuria was the first symptom. This is slightly higher than the incidence of gross hematuria, as the initial symptom, in 902 cases reported by the Committee on Carcinoma Registry. The percentage in these cases was 63.5.

The order of occurrence of initial symptoms which directed these patients to seek medical advice are listed as follows:

Initial Symptoms	No. of Cases
Gross hematuria.....	142
Frequency of urination.....	40
Pain.....	9
Dysuria.....	7
Complete retention.....	3
Pyuria.....	2
Burning.....	2
Incontinence.....	1
Uncertain.....	5
Total.....	211

This group of cases consisted of 210 malignant tumors of epithelial origin and one sarcoma. Of the epithelial tumors in which biopsy studies were made thirty-nine were of the flat infiltrating type and 103 were papillary carcinomas.

Accurate history taking will elicit significant points regarding the patients' occupation, since it has been shown by many investigators that among anilin dye-workers the incidence of cystitis, papillomatosis and papillary carcinoma of the bladder is much higher than in the ordinary population. None of the patients in our series gave a history of having worked in any of the dye industries.

Most tumors of the bladder occur between the ages of forty-five and seventy years and men are found to be afflicted about three times as often as women. In the group of cases we reviewed, 59.9 per

cent of the patients were found to be between the ages of fifty and seventy. The possibility of bladder tumors being incident to bilharzial infestation could be established by learning whether or not the patient had ever resided in a tropical country.

*Physical Examination.* Unlike the hypertensive, the peptic ulcer, or the gall-bladder patient, the individual with cancer of the bladder is not a characteristic type. He may be of any physical stature and personality pattern. Careful physical examinations are prerequisites because the surgeon is then better fortified to plan his program of therapy. Secondary complications of cancer of the bladder should be searched for because they are frequently present. Rectal and vaginal examinations in cases in which there is palpable induration of the bladder wall are of great diagnostic significance for extension of cancer beyond the bladder wall may thus be detected.

Bimanual palpation is an important aid particularly in ascertaining the presence of peritoneal involvement, especially in tumors located in the bladder vault. Physical examination is usually negative in cases with pedunculated growths except when they are of extremely large size and in such instances they may be palpable suprapubically.

In presenting a complete picture of cancer of the bladder it is not sufficient to make the diagnosis and grade its malignancy, but every effort should be made to determine whether or not local or distant metastasis has occurred. This is very important because this one factor will frequently decide whether or not radical surgical treatment should be advised.

It has been rather generally accepted that metastasis from carcinoma of the bladder does not occur until late in the course of the disease. This is undoubtedly true for grades I or II but with the infiltrating tumors hidden metastases are probably present earlier than we suspect. In the report of the Tumor Registry the incidence

of metastasis is 10 per cent. This figure, however, is based on physical and x-ray examinations and no estimate of the deep lymphatic or small visceral metastases could be included. The report also stated that from the data sent in on many of the cases it was evident that they had not been examined for metastases. A more diligent routine search will probably give us a higher percentage for metastases present at the time the patient is first seen. Such a study should include x-ray examinations of the lungs, lumbar spine and pelvis as well as a careful examination of the superficial and deep regional lymph-nodes and the liver. From the seventy-two cases on which sufficient information concerning metastases was submitted to the Carcinoma Registry the distribution was given in fifty-eight. These reports indicated that the bones were most frequently involved. Then in decreasing order of their frequency were the following: the lungs, regional nodes, liver, retroperitoneal nodes and the peritoneum.

Vault tumors with the rich lymphatic drainage along the hypogastric chain of lymphatics metastasize to the liver or by local extension involve the peritoneum. In one of our cases a vault tumor extending to the anterior bladder wall metastasized to the brain and the patient died with a hemiplegia. For practically all bladder carcinomas, except the tumors of the upper portion of the bladder, the first line of metastasis is along the lymphatic chains from the base and lateral walls of the bladder up to the nodes at the bifurcation of the aorta. The diagnosis of this extension is very difficult since these nodes almost never enlarge enough to produce edema of the lower extremities as is seen so frequently with embryonal carcinoma of the testicle and occasionally with carcinoma of the prostate. Metastasis to the lymphatics in the pelvis and along the lumbar spine may be suggested by pain in the lower part of the back, lower extremities and perineum. This is a referred pain and is due to involvement of the perineural as

well as the periovascular lymphatics. As this type of infiltration advances the bones of the pelvis, lower vertebrae and femures are invaded. When segmental resection, total cystectomy or ureteroenterostomy are contemplated, added significance is attached to the diagnosis of perivesical extension and metastasis, for in their presence these attempts to cure the patient completely would be futile. Since involvement of the deep pelvic lymphatics, the aortic nodes or those at bifurcation of the iliac vessels can be detected only by intraperitoneal exploration, this should always precede the attack on the bladder proper or the ureters. By opening the peritoneum one can also better judge the extent of the bladder tumor itself as well as peritoneal encroachment. This exploration can then be continued by palpation of the liver for the discovery of small, secondary nodules.

In the general evaluation of a patient with a diagnosis of cancer of the bladder his age, ordinary life expectancy, degree of present suffering renal function and infection and his ability to stand surgery must be considered before the appropriate treatment selected for his grade of tumor can be planned. While most infiltrating carcinomas are seen in people in the fifties and sixties, occasionally a grade iv, in the absence of demonstrable metastasis total cystectomy with large bowel transplantation of the ureters might be recommended. Yet a diagnosis of even a lower grade tumor in a poor risk or older person might call for cystectomy and cutaneous ureterostomy. With the same tumor diagnosis and a still worse surgical risk deviation of the urinary stream by cutaneous ureterostomy without cystectomy may afford some relief. The same relief is not obtained by suprapubic cystectomy because the trauma of the tube in the bladder again gives rise to pain. The indications for total cystectomy with ureteroenterostomy as well as the operative technic have been very clearly described by Priestley and by Higgins. Cutaneous ureterostomy with or without total cystectomy for carcinoma of the

bladder has been advocated by Beer, Folsom and O'Brien and by Goldstein.

*Urinalysis.* Blood cells in the urine are found in all cases of cancer of the bladder. The blood may be present in various amounts from a few cells seen on microscopic examination to massive hematuria with many blood clots. Careful study sometimes reveals the presence of tumor cells. Pus cells are present in direct proportion to the degree of secondary infection. A small amount of blood in the urine is best detected by the orthotolidine test which is sensitive up to one part of blood in 24,000 parts of urine. The importance of blood in the urine even in minute amounts cannot be too strongly emphasized, and warrants complete urological investigation to determine its origin. It has been estimated that approximately 50 per cent of all patients with gross hematuria have bladder cancer. As mentioned above the incidence of gross hematuria as the presenting symptom in our group of cases was 67.3 per cent.

*Classification.* At one time the diagnosis of cancer of the bladder or papilloma of the bladder was enough information for a referring doctor. Depending on which one of these diagnoses was made, he was able to form an opinion regarding the probable course of the disease and the accepted treatment in either case. Now, with the advent of total cystectomy, the more frequent use of partial resection of the bladder, the question of how much fulguration and diathermy will do, the variable results of irradiation therapy and the problem of the proper disposition of the ureters, a more precise diagnosis is highly desirable. The type of tumor and the degree of its extension as well as its primary location and size determine what manner of management will best suit each individual patient. In order that the doctor who first sees a case of tumor of the bladder may give good counsel to his patient he should have a fairly good impression of what the urologist sees through the cystoscope and what the pathologist sees microscopically. To state that there is a papillary or sessile



growth would be inadequate information and to describe the tumor in detail would be confusing to those unfamiliar with cystoscopic pictures and histologic changes. To simplify the conveyance of the urologist's opinion a standard classification or grading of tumors of the bladder seems necessary. A generally used rough grouping is to refer to them as papilloma, papillary carcinoma or flat infiltrating carcinoma. A more accurate description would also take into consideration the character of the cells and the stroma architecture as well as the probable extent of infiltration into the bladder wall. Such a method of grading was advanced by A. C. Broders of the Mayo Clinic in 1922, when he classified epitheliomas of the genitourinary organs and placed them in four groups according to the degree of cell differentiation. According to this method all the epithelial tumors would be divided as follows: If about three-fourths of the epithelioma consists of differentiated epithelium and one-fourth undifferentiated, it is graded I; if the differentiated and undifferentiated epithelium is about equal, the tumor is graded II; if the undifferentiated epithelium forms about three-fourths of the tumor, it is graded III; if there is no tendency to cell differentiation, the tumor is graded IV.

The writers employ Broders' classification of bladder tumors and likewise call all epithelial tumors carcinomas. The so-called benign papilloma falls into the group referred to by Broders as grade I and this type of tumor is both grossly and microscopically benign. Cystoscopically, these tumors are observed to be composed of a short stalk or pedicle which springs from the bladder mucosa and ends in numerous frail branches or tendrils of various lengths which float in the fluid and are stirred by the least agitation or current. Microscopically the stalk is composed of a central blood supply surrounded by loose connective tissue and covered by layers of epithelial cells. Such a tumor presents no evidence of malignancy, either gross or microscopic at the time of examination but

it is generally agreed that these are prone to undergo malignant change. These tumors may occur in various sizes and may occur as multiple growths in various parts of the bladder.

We have noticed a definite distinction between the single and multiple type of papilloma. The single so-called benign papilloma nearly always responds to electrocoagulation with a permanent cure. It is true that early multiple papillomas on histological examination are placed in the benign group; but because of their marked tendency to continue to recur over a period of many years, despite intensive treatment, the writers regard multiplicity as an evidence of malignancy and believe they should be classified as grade II.

Among the cases we reviewed there was one of a woman age fifty years who on first examination showed multiple papillary tumors. The bladder was opened suprapubically, biopsy specimens taken and the tumors destroyed by diathermy. In this process the entire bladder mucosa was seared as described by Deming. The histopathological report was multiple benign papillomas. This patient returned three months later to show on cystoscopic examination an extensive recurrence of papillary growths which on histological examination were definitely malignant and were classified as grade II. Total cystectomy was then performed.

Another case in this group demonstrates the long period of time over which these multiple tumors continue to recur. This patient was a male aged fifty-six, who was first seen at the age of thirty-nine complaining of gross, painless hematuria, and nocturnal and diurnal frequency of urination. About three years prior to his first visit he had one episode of gross, transient, painless hematuria. Cystoscopic examination revealed multiple papillary tumors over the base of the bladder. Suprapubic cystotomy with excision of the masses and cauterization of their bases with the Percy cautery was performed. Histological diagnosis was papillary carcinoma. He made

an uneventful recovery and was not heard from again for sixteen years. At that time he again complained of the same symptoms which had been present for two weeks. During the interim he had one attack of gross bleeding four years previously. On opening the bladder numerous papillomatous growths were widely distributed over the entire floor and vault of the bladder. Destruction of the tumors was accomplished with the Percy cautery. The specimen for biopsy showed papillary carcinoma grade II. He returned again at the age of fifty-six almost twenty-one years after his first attack of gross hematuria and almost eighteen years after the first destruction of his tumors. Suprapubic cystotomy was now performed for the third time and three superficially ulcerated growths, each the size of a pigeon's egg, with broad bases were removed. The pathologist reported them as grade II papillary carcinomas. However, we believe that a more correct classification for multiple tumors of this size with broad bases would be grade III.

Tumors that are classified as grade II present microscopic evidence of malignant change such as a tendency to produce numerous new branched papillomas with less piling up of the hyperplastic epithelium. Then, too, the microscope will reveal that the epithelial cells are hyperchromatic and their nuclei are of large size and irregular shape. A few mitotic figures may be seen. Cystoscopically, it may be impossible to tell a grade I from a grade II. Infection and ulceration of a papilloma are more prone to occur in a grade II than a grade I. Increase in the thickness of the pedicle as observed cystoscopically is an indication of malignancy and removes a papilloma from the grade I class to the grade II.

Tumors that fall into grades III and IV are of the infiltrating type and on microscopic examination the following features are noted: A small percentage of cell differentiation or absence of cell differentiation, numerous mitotic figures, squa-

mous metaplasia, keratinization and pearl formation. The difference between a grade III and a grade IV cancer is one of degree rather than kind. The malignant features of a grade III cancer are present in a grade IV to a greater degree. Cystoscopic examination in such cases will reveal the papillary tumors to have thick pedicles and the mucous membrane at the point of attachment is thickened and adherent to the submucous structures. In general the villi are shorter and less regular in size and shape. Various degrees of necrotic change may be seen and the villi are very friable. The sessile types are quite nodular in character and in many instances an area of ulceration will be seen in the center of such a cancer. The bladder capacity is invariably reduced in cases in which the tumor is of a grade III or IV. Early sessile carcinomas may present very little cystoscopic evidence of their presence.

*Cystoscopy and Biopsy.* Cystoscopy is the most important procedure in determining the type of lesion causing hematuria. It will serve to differentiate the various urinary lesions which may cause hematuria, dysuria, frequency of urination, etc. Many workers rely almost entirely on the cystoscopic appearance for selecting the choice of treatment rather than the histopathological picture as disclosed in biopsy studies. We, however, believe that cystoscopy alone does not always fortify the surgeon with sufficient preoperative information. In addition to cystoscopy, biopsy and roentgen studies should be made by all means except when the tumor is obviously a grade I papillary carcinoma. The cystoscopic appearance of the epithelial tumors has been described above. Careful records of the cystoscopic findings should be made and they should include the size, number and location of the tumors. These records will prove valuable in surgical management and particularly for the periodic postoperative cystoscopic examination.

The ureters should be catheterized and specimens of urine from each kidney

examined for pus cells. If present, a Gram stain and culture should be made to identify the causative organism so that we may more intelligently manage the eradication of any upper urinary tract infection before surgical treatment is started. At this time the function of each kidney can be estimated and retrograde pyeloureterograms made.

Difficulties in cystoscopic examination are most frequently encountered in those cases of bladder neoplasia with marked secondary infection. In such cases infection should be combated carefully and the patient re-examined at a later date. The arrest of the infectious process will facilitate any subsequent surgical procedures. Incidentally, in clearing up these infections implanted on ulcerating carcinomas with the appropriate sulfonamide drug we have noticed a striking symptomatic improvement.

Hemorrhage will not prevent an accurate cystoscopic inspection except in extreme cases if care is taken to wash out all of the blood clots. The cystoscopic examination should be a very thorough one and if necessary, it should be done under anesthesia because a fleeting glance of a tumor is not adequate. The size, location, number, character of the pedicle, the type of tumor and evidence of infiltration are important points that one must ascertain by cystoscopic inspection. Tumors of grades III and IV are prone to undergo necrotic change and promote various degrees of secondary infection. Sessile tumors present crater-like ulceration in their centers, while papillary tumors may undergo severe sloughing of the villi and pedicle itself. The location of tumors has great significance since those on or about the trigone are not so amenable to excision or segmental resections as those occupying the movable portions of the bladder. It is unfortunate that the vast majority of tumors arise in the more fixed portion of the bladder. Some of these tumors are located so close to a ureteral orifice that their destruction or removal entails the sacrifice of the intramural por-

tion of that ureter. In such cases intracystic transplantation of the ureter must be planned for as part of the operative management.

In a report of the Bladder Tumor Registry on a series of 902 cases of epithelial tumors their locations were listed as follows:

Region	Per Cent
Trigone	32 2
Lateral walls	35 3
Bladder neck	9 0
Posterior wall	10 2
Vault	7 5
Anterior wall	5 7

Over fifty cases of primary carcinoma of the bladder arising in vesical diverticuli have been reported. Higgins collected forty-nine cases from the literature in 1936; Heslin and Milner added one case in 1938 and Clancy reported another in 1941. Hematuria is again the cardinal symptom and was found in 77 per cent of the cases reviewed by LeComte, and 83 per cent of those reviewed by Higgins. On cystoscopic examination in cases with hematuria in which a vesical diverticulum is the only pathological finding, careful search for cancer concealed within the diverticulum must be made. Stones within the diverticulum may be easily ruled out by plain x-ray plate. In some cases the cystoscope can be introduced into the diverticulum and the cancer tissue observed.

Cystography is very valuable since filling defects will usually be seen in diverticuli that harbor a neoplasm. In some cases the tumor can be seen on cystoscopic examination through the mouth of the diverticulum or protruding from it. The authors have had experience with one case of primary cancer of the bladder occurring in a diverticulum and in this case cystoscopic examination was negative except for the presence of a diverticulum. The diverticular os was too small to permit insertion of the cystoscope; however, by gradually deflating the bladder the tumor plainly presented itself at the os of the diverticulum. We recommend this procedure as an additional aid in the cystoscopic diagnosis

of vesical carcinoma primarily located within a diverticulum.

The accuracy of biopsy diagnosis has been pointed out by Aschner who found that in 97.5 per cent of 242 cases the diagnosis was confirmed. Biopsy specimens are readily obtained by one of the various cystoscopic rongeurs. In securing these specimens care must be taken to include sections from the pedicle and base and with papillary growths very often most of the tumor has to be resected before the base can be exposed. The removal of the villous portion of these tumors by drawing the loop of the resectoscope into the sheath without the use of any current has the advantage of protecting the base and pedicle from the distorting effects of heat on the biopsy specimen. Occasionally, one can detect nodularity of the mucosa surrounding the pedicle. This is suspicious of extension and this area should have microscopic study. In taking fragments from the papillary growths it is important to select the more atypically shaped and more rigid fronds. A more composite histologic picture is achieved when different regions of the mass are represented. When the neoplasm is flat, ulcerated or necrotic, the central portion should be avoided since the margin of the ulcer with part of the indurated edge is more apt to show the true character of the lesion.

In certain cases in which submucosal invasion has progressed some distance from the primary site the cystoscopist will detect an abnormal adherence or fixation of the vesical mucosa to the submucosal structures. With grades III or IV tumors, sessile or papillary, we recommend the taking of several specimens from scattered areas in the bladder in an effort to determine the extent of suspected infiltration. This information is especially necessary when making a decision between segmental resection and total cystectomy.

Needless to say, the removal of specimens, from a thin bladder wall, ulcerated flat carcinoma or a tropic ulcer, requires considerable cystoscopic finesse to prevent

the necessarily sharp jaws of the rongeur from including too much of the musculature in their bite. If there is the slightest doubt regarding the integrity of the vesical wall at the completion of the procedure, an indwelling urethral catheter should be kept in place for four or five days, and the patient should be closely watched for any signs of bladder perforation. If these are found, of course, suprapubic cystostomy and generous perivesical drainage especially at the site of rupture should be provided.

Improvements in the cutting current and the more popular use of the resectoscope have brought about a splendid advance in the treatment of tumors of the bladder but accurate diagnosis has probably been retarded by using the tissue, seared by the cutting current, for biopsy material. It is certainly true that when a large piece of tissue is removed in this manner the portion, most distant from the cut surface, will be practically just as valuable to the pathologist as if cut by the rongeur; but for our most important sections, when seeking early infiltration in a pedicle base or beyond the site of the visible tumor, the amount of tissue removed must, of course, be small. In these small sections the heat from the loop can alter the appearance so much that the pathologist will have difficulty in making a reliable diagnosis.

Another form of therapeutic progress which might easily lead to a considerable reduction in the percentage of completely correct diagnoses is electrocoagulation. The refinements in electrocoagulating equipment and the excellent results they so often produce may very well tempt an optimistic urologist to destroy the tumor without taking a biopsy specimen. The obvious danger in such a practice is that occasionally on cystoscopic examination a tumor appears small and innocent enough to respond to electrocoagulation but actually has a high percentage of undifferentiated cells and unsuspected invasive powers. After one or more recurrences with attempts at destruction by heat a histo-

pathological diagnosis is desired. At this stage, however, the biopsy material will often consist of a section of sloughing surface leaving undisturbed the deeper malignant process or the secondary inflammation may make a diagnosis still uncertain. In this manner one can see how such diagnostic management can repeatedly delay the institution of proper treatment. A more satisfactory method which avoids these pitfalls in the diagnostic process is to remove bits of tissue from precisely selected areas of the tumor or bladder and then use electrocoagulation when this is indicated by the cystoscopic appearance. Then after histological examination, if a higher grade of malignancy is found, we can proceed with more radical treatment.

*Cystography and Urography.* Valuable information can be obtained if a series of cystograms are made in cases suspected of being infiltrating cancers. Reference is made particularly to those cases in which extensive infiltration of the bladder wall is present and cystoscopically one may see a relatively small and innocent looking lesion. Cystograms or pneumocystograms of such cases will show irregularities in the mural contour of the bladder, the site of infiltration being represented by an area in which the bladder wall does not stretch normally. Such findings are in our opinion almost pathognomonic of an infiltrating neoplasm. With invasion of the intramural portion of a ureter we look for cystographic evidence of a reflux of the contrast medium in the affected ureter. The cystogram may also be useful in determining the size and location of certain papillary tumors but it should be employed essentially as a supplement to the cystoscopic examination. Careful and complete studies of the upper urinary tract should be made because the type of surgery, planned for handling cancer of the bladder, may depend on the status of the kidneys and ureters. In some cases ureteral obstruction will be present as a result of invasion of the intramural segment of the ureter. Under such circum-

stances dilatation of the ureter and various degrees of hydronephrosis and pyelonephritis may have occurred. Occasionally, the obstruction of the intramural segment of the ureter will enable one to indict as infiltrating a tumor which appears cystoscopically to be of a lower grade. Furthermore, if such a tumor is located some distance from the orifice of the obstructed ureter one may assume that it must be a very malignant growth if it has traveled, hidden beneath the mucosa, for that distance. Briefly it may be said that the greater the distance between the primary neoplasm and the obstructed ureter the greater the degree of malignancy.

Complete knowledge of the condition of the ureters is again imperative when the surgeon elects to divert the urinary stream. Obstruction and ureteritis may have produced dilatation and areas of stenosis. With ureters which are ~~very~~ much dilated ureteroenterostomy is difficult and hazardous, while on the other hand such ureters are well adapted for cutaneous ureterostomy. Cutaneous ureterostomy with small calibered ureters leads to considerable discomfort occasioned by the large tubes necessarily kept continuously in the ureters to the renal pelves. If smaller tubes are used, they are apt to provide inadequate drainage and require too frequent replacement.

*Differential Diagnosis.* In the differential diagnosis of carcinoma of the bladder one must consider several other prominent causes of gross hematuria as well as a few of the causes of dysuria, frequency and urinary retention. The hematuria and other symptoms of acute or subacute cystitis will frequently lead one to consider tumor of the bladder. In some of these cases even on cystoscopic examination extensive bullous edema, ulceration, grey exudate or thickening of the bladder mucosa may appear the same as that seen about a carcinoma. When there is no underlying pathological lesion in the bladder or adjacent structures, the inflammatory

process will readily respond to the appropriate urinary antiseptic. When the cystitis is secondary to carcinoma of the bladder, there is often a similar subsidence of symptoms and a disappearance of the edema, exudate and mucosal congestion while the patient is having local therapy or taking the urinary antiseptic. However, this improvement quickly gives way to an exacerbation of the cystitis, on discontinuing treatment, if a tumor is present. This treatment of the superimposed infectious process can be of great diagnostic assistance. Usually about one week after therapy is started the second cystoscopic examination will reveal an unmasked tumor which can then be clearly inspected. In the meantime this process will prove very gratifying to the patient for in the absence of or even with a decrease in the severity of the inflammatory reaction he is appreciably relieved of his dull continuous pain, dysuria, frequency and urgency and even retention of urine and hematuria may be less pronounced.

The removal of the disguising infection is especially important prior to securing material for histologic examination since biopsy in the presence of severe cystitis is unreliable and may be dangerous. The specimen removed may include only the edematous portion and leave intact the deeper malignant cells. When inflammation alone is present, the cutting blades of the rongeur can bite so much of the bladder wall that the infection can spread perivesically and set up retroperitoneal infection or peritonitis.

*An incrustated cystitis* can resemble carcinoma so closely that only by biopsy can they be differentiated. Its chronicity and the ammoniacal urine with blood, pus, mucus and necrotic tissue suggest carcinoma. Then on cystoscopy, the calcareous incrustations and necrotic membranes, often forming pseudofronds, can still cause uncertainty regarding malignancy, since the flat infiltrating carcinoma may present an identical appearance. The finding of urea-splitting organisms in the urine is of

little help because they also commonly accompany carcinoma.

*Cystitis cystica* can occasionally resemble carcinoma of the bladder. The characteristic, small translucent cysts of cystitis cystica may be so closely grouped that they seem confluent. At this stage the collection of cysts can appear exactly like a patch of bullous edema and for this reason carcinoma may be suspected. The lack of induration in the bladder wall and biopsy will make the diagnosis certain.

*Cystitis follicularis* with its solid, rounded, nodules of lymphoid tissue beneath the epithelium is not likely to be confused with carcinoma unless the urologist is searching for extension in the vesical wall from an infiltrating carcinoma elsewhere in the bladder. Biopsy may be necessary for final diagnosis.

*Renal, ureteral or vesical calculus* can simulate tumor of the bladder by the gross hematuria and the frequency they produce. A stone impacted in the intramural portion of the ureter can seldom lead one to think of a tumor. With stone in the upper urinary tract the renal colic or dull pain indicate that there is also ureteral obstruction. With urograms and catheterization of the ureters the presence or absence of stone is easily determined. Only on rare occasions is this type of pain an early symptom in carcinoma of the bladder. However, in the later stages the tumor nearly always invades the region of one or both ureteral orifices and causes obstruction. The infection and renal damage incident to this type of obstruction from infiltration of carcinoma account for more deaths than those caused by metastatic lesions or perivesical extension of the disease. Caulk, in analyzing the records of the cause of death in ninety cases, found renal disease in 38 per cent of them. Of these cases twenty-five came to autopsy and in fifteen or 60 per cent the cause was in the kidneys.

*Acute diffuse nephritis* is not an uncommon cause of hematuria and it frequently must be distinguished from surgical conditions in the urinary tract. Here urinalysis

will show more albumin than one would expect from the amount of blood in the urine and hyaline and granular casts will be found if a centrifuged specimen is examined. The symptoms and findings in nephritis can easily delay the diagnosis of an early co-existent cancer of the bladder. Only by cystoscopy or urography can we be entirely certain about such a complication.

*Benign prostatic enlargement, carcinoma of the prostate and varicosities* in the posterior urethra are causes of gross hematuria, dysuria and frequency, but by combining the findings of rectal examination and cystourethroscopic examination there will be little difficulty unless an infiltrating carcinoma of the base has invaded the prostate as it does in about 12 per cent of bladder carcinomas. Carcinoma of the prostate may also extend upward at the bladder neck. In either case biopsy is often necessary to establish the site of origin.

*Tuberculosis* in the bladder has symptoms similar to those of cancer of the bladder but in very few cases will cystoscopy and visualization of the upper urinary tract fail to distinguish them. The characteristic destructive process in the kidney and the chronic inflammatory changes in the ureter are distinctive. The ulcers of tuberculosis are usually multiple and have little elevation in contrast to the ulcer of the single sessile carcinoma.

*Hunner's ulcer (localized submucous fibrosis)* in its more severe form can possibly be confused with carcinoma. The symptoms of severe pain, frequency and intermittent hematuria together with ulceration in a contracted bladder, which is difficult to inspect without general anesthesia, are somewhat similar to those of a flat infiltrating tumor. A long history of frequency and pain which is knife-like in character and intense when the bladder is full and made worse by jarring the body is typical of Hunner's ulcer. The diagnosis is made of cystoscopy which will show ulceration or linear abrasions of the mucosa which bleed easily when touched or on distention of the bladder. They are practically always on the

vault or moveable portion of the lateral and posterior walls.

*Extravesical inflammatory lesions* such as diverticulitis, carcinoma of the rectosigmoid, acute appendicitis, pelvic inflammatory disease, dermoid cyst and endometriosis can cause a localized reaction with bullous edema and congestion of the bladder mucosa. A grey exudate, ulceration and bleeding frequently are seen. The localized lesion is usually on the posterior or lateral walls. The cystogram may give a picture very similar to that of infiltrating carcinoma with rigidity in part of the bladder wall. Vaginal or rectal examination and bimanual palpation will usually disclose the nature of the extravesical lesion. Sigmoidography combined with the cystogram is informative especially if there is an intestinal diverticulitis or carcinoma of the sigmoid. When an endometrial implant invades the bladder it appears on cystoscopic examination as a tumor usually between the ureteral orifices or just posterior to this location. If it has involved the mucosa, it bleeds easily and is associated with bullous edema. A history of aggravation of the chief symptoms, which are frequency, dysuria and suprapubic pain, during the menstrual periods prompts a further search for signs of endometriosis in other locations such as a nodular thickening in the cul-de-sac. Cystoscopic biopsy, on an endometrial tumor in the bladder and on the other extravesical lesions, should be done only when all other efforts have failed to establish the diagnosis. The danger of biopsy in these conditions is that it may aid in the formation of a vesico-intestinal fistula.

*Trophic ulcer*, the result of irradiation of the cervix or body of the uterus, may be easily mistaken for a flat, ulcerated carcinoma of the bladder base. The cystoscopic pictures may be identical and the symptoms of frequency, hematuria and dysuria, which is intense, are so protracted and disabling that cancer is always suspected. The microscopic examination may mislead the pathologist and he also may make the

diagnosis of carcinoma of the bladder because of the late tissue changes caused by irradiation. The ulcer nearly always occurs in the midline just behind the interureteric ridge. It is produced by the blood supply to that part of the bladder wall. It would be a very grave error to consider this lesion a carcinoma and for it advise more radiation therapy, which obviously would lead to disastrous results.

On cystoscopic examination the ulceration is seen in sizes varying between 5 mm. and 5 cm. in diameter. It is accompanied by bullous edema and a chronic inflammatory reaction around it while in the center is a grey slough or necrotic area.

Vaginal examination is very enlightening because the thickened indurated bladder floor of carcinoma is not felt even with very large trophic ulcers.

The history of having had irradiation of the uterus will aid in establishing the diagnosis but since the ulceration occurs between one and ten years after exposure the patient may fail to volunteer this information. In studying the time of onset of bladder symptoms in twenty-four patients Dean found that the average was two and one-half years after irradiation.

*Bilharziasis of the bladder* may easily be confounded with carcinoma if we rely on the cystoscopic picture alone. The early lesions are small papules with raised, yellow centers or ulcers. Later, sessile or papillary granulomas develop and these have a neoplastic appearance. With ulceration there is secondary infection with calcareous deposition and induration of the bladder wall. Biopsy will distinguish it from carcinoma and in the biopsy material the ova may be seen. The urine always contains these ova and they can usually be demonstrated. They appear as long ovoids with narrowing at one end where a spine is attached. Bilharzial infestation in the terminal venules and capillaries of the submucosa is followed by deposits of ova which become encysted and it has been noted that in these areas of the bladder malignancy

itself not infrequently develops. The history of having visited Africa or Egypt is a significant aid in diagnosis.

*Mesothelial tumors* of the bladder may be rebenign or malignant and in either form a very rare. They are distinguished from carcinoma by biopsy since there is little difference in their cystoscopic or cystographic appearances. The rapid growth and failure to produce symptoms until the mass is very large suggest that it is not an epithelial tumor. The epithelium seems to remain intact and hematuria is a late symptom. One of our cases was a sarcoma in a man forty-two years of age. Hematuria was the first symptom and was not noticed until two weeks before admission to the hospital when we found a spherical mass, completely filling the bladder, attached by a small pedicle. The more firm benign mesothelial tumors are frequently found by the patient who palpates the mass in the hypogastrium.

*Secondary carcinoma* from a papillary carcinoma of the renal pelvis may be seen protruding from a ureteral orifice or as multiple papillary growths distributed closely about one ureteral orifice. These are eliminated from diagnostic consideration as primary bladder tumors by demonstrating the primary renal carcinoma and possible ureteral growths by retrograde pyeloureterograms.

*Recurrent carcinoma* of the bladder at the site of a previously destroyed or removed tumor may present difficulties in diagnosing its presence or in differentiating it from a new, primary carcinoma arising elsewhere in the bladder. A detailed record of the location of the original growth will distinguish between the new tumors and recurrences. However, changes brought about by irradiation or electrocoagulation used in the treatment of the original tumor may hide the early recurrent carcinoma. The microscopic as well as the cystoscopic appearance may be deceiving. An increasing area of ulceration, persistent bleeding and marked calcareous incrustation should



make one suspect a recurrent or remaining carcinoma. Usually within six months after the destruction of even a large tumor the healing process is complete. It is only by familiarity with the ordinary tissue response to heat and irradiation and by repeated cystoscopic inspection that we can recognize the new tumor tissue, springing up in the midst of a devitalized area or in the surrounding zone of inflammation, early enough to apply effectively the same treatment or to institute hopefully more radical measures. It is for this reason and also to discover new growths early that the urologist should keep an additional appointment book just for patients with tumors of the bladder. The ordinary words of caution and instruction to return on a certain date do not seem impressive enough to bring the symptomless patient back for re-examination. Routine letters reminding them of the importance of keeping this condition under control and assigning them specific dates for examination may prove more persuasive. Counseller and Walters request these patients to return twice at three-month intervals, then six months later and again in one year. These examinations should include periodic cystoscopy regardless of the absence of microscopic hematuria, for new tumors or a true recurrence may attain a large size before the patient is examined at a time when red blood cells appear in the urine.

#### SUMMARY

The important clinical and particularly the diagnostic features of carcinoma of the bladder have been examined. The value of the case history, physical examination, urinalysis, classification of epithelial tumors, cystoscopy, biopsy, roentgen studies and differential diagnosis have been outlined. Certain points have been emphasized by reference to cases which the writers have examined. The writers believe that the problem of cancer of the bladder can be handled in a more satisfactory manner if the surgeon is fortified with complete

knowledge of the urinary tract prior to operation.

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\* Due to lack of space a few references have been taken out. However, these references will be included in the reprints.

# General

## DIAGNOSIS OF DISEASES OF THE THYROID GLAND

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WE believe that diseases of the thyroid gland amenable to surgical attack are always associated with enlargement of the gland, in whole or in part. The first question to be answered, therefore, in examining a patient suspected of having a disorder of thyroid function, is "Has he a goiter?" If the answer is in the negative, the overwhelming probability is that clear evidence of thyrotoxicosis will not be brought forth by systemic examination and by laboratory investigations. The writer regards as a myth the view that there is in the human subject any degree of thyroid intoxication not accompanied by enlargement of the gland. We see, not infrequently, thyrotoxic patients whose goiters seem obvious to us and in whom the diagnosis of toxic goiter is confirmed anatomically but in whom enlargement of the gland is not detected by able physicians though they have readily recognized the systemic manifestations of hyperthyroidism. We see rather more patients diagnosed elsewhere as being hyperthyroid in whom we can neither confirm the diagnosis of hyperthyroidism nor detect any enlargement of the gland. Without wishing to labor the point one may add that there is no substitute for experience in the palpation of enlargements of the thyroid and we have not, personally, seen a case in which the diagnosis of hyperthyroidism was borne out by anatomical diagnosis or by clinical response to nonoperative management in which the enlargement of the gland was not palpable. (It should be understood that this statement bars from consideration goiters which are entirely intrathoracic.)

There is ample opportunity for humility, however, when one attempts to predict the exact size or extent of the goiter and the precise nature of the goitrous tissue, as will be discussed. Suffice it to say that it is axiomatic with us that the goiter will prove to be bigger at operation than we have anticipated from examination of the neck.

### EXAMINATION OF THE NECK

In a favorable light the diagnosis of even small goiters can be made with considerable certainty at a distance by observation of the rise and fall during deglutition of the shadow when the skin is molded by the pressure of an enlarged thyroid. Asymmetry of an obvious swelling will ordinarily indicate the presence of a nodular gland. The presence of rapid expansile neck pulsations transmitted from the carotid arteries and jugular veins gives an indication of the cardiac rate and is, further, an expression of the wide pulse pressure of thyrotoxicosis. Similarly, flushing of the skin of the neck is due to arteriolar and capillary dilatation and is common in thyrotoxicosis though by no means pathognomonic, particularly if transient, for it accompanies the rapid fluctuations of arterial blood pressure and vasomotor tone seen in patients with a variety of conditions characterized by emotional lability. Congestion of the external and anterior jugular veins and a dull suffusion of the face, sometimes unilateral, indicate such obstruction of the tributaries of the superior vena cava as occurs with goiters of considerable size which fill the superior thoracic strait or descend into the anterior

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mediastinum. Further examination will indicate whether this phenomenon is a concomitant or is independent of congestive heart failure; the two situations frequently co-exist. Wildly, irregularly filling superficial jugulars are often a clue to auricular fibrillation. Auscultation over the cardinal vessels (superior and inferior thyroid arteries) will reveal the presence or absence of bruits. These are *rarely* heard in the absence of hyperthyroidism. Light palpation over the vessels enables one to detect thrills in the arteries; again, practically pathognomonic. Thrills and bruits are less apt to be present in the lower grades of hyperthyroidism, especially those associated with nodular goiters, and they disappear under treatment somewhat earlier than the precordial, blowing systolic murmur so characteristic of rather acute hyperthyroidism.

The position of the patient during palpation of the neck may help or hinder accuracy in examination. The patient is ordinarily examined in the sitting posture and instinctively extends the cervical spine, raising the chin and putting the sternomastoids and prethyroid muscles on such tension as to make more difficult palpation of the gland. The cervical spine, therefore, should be in an easy, slightly flexed position during preliminary palpation in order to relax all the muscles superficial to the gland. The lateral lobes and isthmus should be felt for in an effort to describe their size, surface characteristics, consistency and mobility on the trachea. The height to which the upper poles extend toward the angle of the jaw and the degree to which lower poles extend toward or beneath the clavicle can best be brought out by having the patient swallow while the examining fingers are gently pressing on the portion of the lobe in question. Details of one lobe can be brought out best then by having the neck rotated *toward* the lobe in question in order to relax the sternomastoid on that side. The writer prefers to stand facing the patient, generally, and to examine the patient's right lobe with his

left hand and the left lobe with his right hand. In each case, the effort is made to palpate the lobe between the thumb, lying medial to the sternomastoid, and the index and third fingers lying lateral to it; meanwhile, the fingers of the other hand, by gently pressing backward on the opposite lobe, rotate the lobe in question *forward* between the examining fingers and thumb. This maneuver is particularly useful in demonstrating the smaller of two lobes in an asymmetrical goiter. At times, further details can be added by standing behind the patient and carrying out palpation of each lobe with the thumb behind the sternomastoid and the index and third fingers anterior to it. Finally, in cases in which the presence of enlargement of the gland is very doubtful or the question of fixation on the trachea is in question, additional information may be obtained by examining the patient in the supine position, since the tumor lies higher in the neck in this position.

The position of the trachea is always of interest and may be of vital importance. It is ordinarily in the midline of the neck in symmetrical, bilateral goiter and may, with a small isthmus, be palpated throughout its extent between the lobes. But if covered anteriorly by an enlarged isthmus and a pyramidal lobe or by a rotated unilateral enlargement it may not be palpable at all. Fetal adenomas of considerable size, particularly when solitary, produce the most marked deviations of the trachea from the midline and their presence should always be suspected when such deviation is found. We are always interested in the character of the opposite lobe in such a case for in the Mississippi Valley we are used to seeing fetal adenomas in glands which are *otherwise* abnormal, i.e., the remainder of that lobe and the opposite lobe usually show varying grades of colloid goiter or of diffuse hyperplasia (particularly the former) or of mixtures of all three processes. On the contrary, authors in the Southwest say that they usually find the solitary adenoma in an otherwise normal

gland. Enucleation of the adenoma is obviously adequate in the latter situation, whereas subtotal thyroidectomy is more suitable to the former in which there is no normal thyroid tissue grossly detectable at operation. The writer must own to a definite percentage of error in the preoperative estimation of the character of the opposite lobe in such cases. The error always lies in the direction of assuming that the opposite lobe will be normal in those cases in which it cannot be palpated with certainty before opening the neck. We are used to finding considerable degrees of *rotation* of the trachea in such cases and in them the opposite lobe may be easily twice normal size and grossly nodular without being felt in the examination of the intact neck. Varying degrees of rotation and tipping of the larynx itself is often present in these cases, particularly if the adenoma is quite large and lies high in the neck; and it may be exceedingly difficult to intubate such patients if intratracheal anesthesia is chosen for them. Retrotracheal extension and enlargement of the opposite lobe is clearly indicated in the case in which one lobe is obviously enlarged, regardless of its character, yet the other lobe is not definitely felt, *if the trachea is in the midline*. In such cases it is the retrotracheal extension of the opposite lobe which *prevents* displacement of the trachea away from the palpable lobe.

The retrotracheal projections of, generally, nodular goiters and the retrotracheal extension of the upper poles, particularly, of diffuse goiters cannot be made out with any certainty in most cases in the intact neck and this is all the more reason that they should be sought out at operation by delivery of the gland from its bed before excision is started; such portions, if overlooked, are, in our own experience, the most common cause of persistent hyperthyroidism. We have come to expect to find deep lying, often retrotracheal upper poles in patients with short, thick necks and the author has not noted elsewhere in the literature in explanation of it the rather

obvious fact that such patients have, as part of their general physical structure, *short superior thyroid arteries* which, particularly if they lie anterior to the thyroid tissue at the upper pole, limit its enlargement in the anterior direction. This seems to the writer a more plausible explanation than the usual one of strong, thick prethyroid muscles in these individuals of sthenic habitus who have also a wide aorta, wide costal angle, short mesentery and correspondingly short abdominal vessels. This observation may well have been made previously but the author has not encountered it and it is certainly not a part of general knowledge of this aspect of the subject.

There are numerous symptoms and physical signs that suggest the extension of goiter into the upper thoracic cage. Typical is the patient's statement that he formerly had a large goiter which has greatly diminished in size or entirely disappeared. The writer has, at the moment, such a patient in the hospital who gave such a history preoperatively and only the very top of whose left lobe could be felt in the neck; it rose but little on swallowing, yet the patient could *cough* the mass (the size of an orange) up into the neck through the superior thoracic strait. Such intrathoracic masses are nearly always extensions downward of goiters whose upper portions can be felt more or less easily in the neck, yet in rare instances an adenoma descends into the thorax and its connections with the remainder of the lobe in which it originated become so attenuated as to be unrecognizable at operation. The author has seen only one such case personally, a thyrotoxic individual with a bilateral diffuse hyperplastic goiter whose lateral lobes were some three times normal size and had small retroclavicular extension of the lower poles. The usual rather radical subtotal thyroidectomy was followed by considerable improvement but with unmistakable persistent hyperthyroidism. Only after eighteen months did a small mass become palpable in the suprasternal notch

and a completely intrathoracic mass the size of a grapefruit was then discovered and removed. At the second operation the remnants of the lateral lobes could barely be identified and there were no fibrous or vascular connections between the structures in the neck and the intrathoracic mass. Complete relief of hyperthyroidism followed the second operation and the anticipated hypothyroidism developed within six weeks. Normal thyroid status is, of course, maintained by thyroid feeding.

A spasmodic, nonproductive cough, episodes of near-suffocation and decided dyspnea on exertion (especially in the absence of hyperthyroidism) are suggestive of tracheal irritation and partial obstruction commonly found in patients with intrathoracic extensions of goiter. The brassy cough, occasional hoarseness and "crowing," particularly on exertion and during sleep, strongly suggest pressure or traction on the inferior laryngeal nerve, but we find these symptoms and signs to be present far more commonly without evidence of nerve injury than with such evidence from visualization of the larynx. The occurrence of venous engorgement characteristic of obstruction of the upper vena cava and its tributaries in connection with intrathoracic goiter has been mentioned previously. Dullness on percussion of the clavicle and subclavicular areas can readily be demonstrated also. Absence of breath sounds anteriorly over the apex of the lung is often found on auscultation. Finally, intrathoracic goiter must be ruled out in those rare patients in whom strong systemic evidence of hyperthyroidism is present with a wholly "unsatisfactory" amount of enlargement of the lateral lobes to account for the systemic findings. In our experience such extensions have occurred almost entirely in individuals of sthenic or hypersthenic habitus. In them the normal location of the gland is not only closer to the superior thoracic strait than that of the asthenic person but the strait itself is larger. It is a fact in such persons that one sees usually nearly as large a portion of

big goiters below the clavicles as above them.

Palpation of the neck in suspected persistent or recurrent hyperthyroidism offers a wholly different set of circumstances for physical examination due to the manner in which scarring in the plane of the pretracheal fascia may limit the forward extension of the enlargement of gland tissue. The diagnosis of thyrotoxicosis is made in any case on systemic, rather than on local, findings and, *provided* the original operator followed the practice of dissecting out the upper poles completely, persistent or recurrent hyperthyroidism in its early stages is usually due to overlooked retrotracheal or substernal projections which continue to hyperfunction and to enlarge in the depths of the neck where they may not be palpable until relatively late.

The methods of examination accessory to the use of one's God-given special senses in the study of the goiter itself are the laryngoscopic mirror and the roentgen ray. All patients for whom thyroidectomy is contemplated should have an inspection of the larynx in order to detect the occasional unsuspected inferior laryngeal nerve paralysis, to determine on which side the involvement occurs, to rule out perforation of the larynx or trachea by suspected carcinoma of the thyroid and to exclude intrinsic diseases of the larynx itself. We regard the existence of inferior laryngeal nerve paralysis as being a practically absolute indication for a two-stage thyroidectomy (regardless of the presence or absence of hyperthyroidism), the lobectomy on the affected side being performed *first* and the second lobectomy deferred until such time as to allow ample opportunity for maximum recovery of function of the impaired nerve. Operative injury to the uninvolved nerve previous to such recovery precipitates, of course, the tragedy of double abducens paralysis and this is a situation that can be tragic enough even though it be but temporary. Finally, only by routine postoperative visualization of the larynx can one honestly evaluate his

own incidence of nerve injuries and thereby alter, as necessary, his technical procedures when the incidence of this complication, frequently unsuspected if unilateral, gets beyond the inevitable minimum experienced by all of us.

X-ray examination of the upper chest and lower neck in the anteroposterior plane and, as necessary, in oblique planes, together with lateral views of the neck are most useful in locating exactly the position of the trachea throughout its course and for the more or less exact definition of retrotracheal and intrathoracic extensions of goiter which are often calcified. We depend on them to guide us toward a more complete evaluation of the mechanical problems involved in certain cases. Whenever it is financially feasible for the patient they make an unquestionably desirable addition to the *routine* of examination of all goiter patients. That they are not routinely feasible in all private practice (i.e., when the patient's own money, rather than someone else's money is being spent on them) is equally unarguable. Only the good judgment of the physician can decide when they are indispensable in the individual case. In any case, it is often possible to achieve the ideal of a routine x-ray film at small cost to the patient by the exercise of ingenuity in obtaining roentgenograms in combination with other specialized forms of expert service from the same source, if the physician is not prepared to deliver them from his own resources. Hospitals are showing a desirable tendency to insist on routine studies in their clinical laboratories on all patients admitted and to set a "flat rate" fee for such admission examinations for a decidedly smaller sum than would have been charged for such examinations if ordered as optional examinations in previous years. Yet the writer suspects that more widely useful information would be obtained from the inclusion of an x-ray film of the chest in such a routine than, let us say, the usual estimation of the nonprotein nitrogen concentration of the blood. One is even more

confident that the accuracy of the film would be higher than that of the biochemical determinations done in the average hospital laboratory.

Occasionally, signs are found on palpation which seriously raise the question of the presence of the relatively uncommon disorders of the gland not considered heretofore. These special findings are hardness of the tissue, fixation of the gland on the trachea or to the overlying muscles and marked tenderness. Acute thyroiditis is prone to follow acute upper respiratory infections and actually occurs far less frequently as a consequence of hematogenous infection during septicemia than one would reasonably anticipate. In our own limited experience it has nearly always occurred in a pre-existing goiter, generally adenomatous, rather than in a presumably normal thyroid gland and, in the days before chemotherapy with the sulfonamides, went on to suppuration requiring surgical drainage more often than it resolved. The involved portion of the gland is swollen, very tender and painful and usually becomes fixed by inflammatory reaction to the surrounding tissues. There is frequently local heat, edema and redness of the overlying skin. Fluctuation is not usually demonstrable until very late because of the tenseness of the capsule and the edema of the prethyroid tissues. One should not wait for demonstrable fluctuation before draining these abscesses.

Hardness and fixation of the gland are common to both chronic thyroiditis of the Riedel type and to carcinomas of the thyroid which have perforated the capsule. Constriction of the trachea is produced in the former case by the contraction of scar tissue; invasion of the trachea is commonly the earliest extension of carcinoma beyond the capsule. Both conditions are accompanied by extension of their peculiar processes to the prethyroid muscles; but regional lymph gland metastasis is frequent in carcinoma whereas enlargement of regional nodes is not characteristic of Riedel's struma. Both diseases are fre-

quently associated with adenomatous goiter and the great majority of carcinomas of the thyroid arise in adenomas. This leads, of course, to the special consideration of adenomas of the thyroid as being always potential "dynamite" as far as the risk of the appearance of carcinoma of the thyroid is concerned. While the fact that approximately 5 per cent of fetal adenomas show carcinomatous degeneration on removal does not mean that 5 per cent of all fetal adenomas undergo malignant degeneration; yet one can only regard such an argument in favor of watchful waiting on adenomas in adults as being wholly specious when one considers that perforation of the capsule and fixation of the gland by invasion of surrounding tissues is the first sign that indicates the presence of carcinoma. No one who has watched a number of deaths from carcinoma of the thyroid will condone an expectant policy with adenomatous goiter, regardless of the state of thyroid function. That true adenomas occur both in glands otherwise normal and in glands otherwise diseased is again beside the point. Certain types of tumors which must be grouped as carcinoma of the thyroid show blood vessel invasion before fixation to adjacent fibrous structures occurs and in them the prognosis is necessarily guarded even though the local excision of the growth is complete.

We have been impressed with the aching discomfort experienced by some of our own patients with Riedel's struma and by the occasional finding of tenderness to palpation in the earlier cases. These are of infrequent occurrence in carcinoma of the thyroid in its early invasive stage before nerve involvement has taken place. It should be noted particularly, however, that the occurrence of sudden pain and increase in size of a previously recognized nodule and the presence of tenderness, all of which are classical signs of hemorrhage into an adenoma, may mark instead the perforation of the capsule of the adenoma by carcinoma with no associated hemorrhage whatever. We have recently seen such a

case at the onset of the discomfort; operation performed within a week of the event disclosed the findings outlined. Finally, the microscopic differentiation between Riedel's struma and certain carcinomas may be exceedingly difficult and the final answer may be obtained in such cases only by the clinical course of the patient.

There are no certain gross criteria for the recognition of Hashimoto's disease (struma lymphomatosa). The process does not extend beyond the capsule of the gland and occurs almost exclusively in smooth goiters. It is associated with normal or decreased thyroid function and is of rare occurrence.

#### THE RECOGNITION OF HYPERTHYROIDISM

The estimation of abnormal thyroid function, let it be repeated, does not depend upon the examination of the neck but upon recognition of the systemic effects of increased or decreased thyroid activity. This is not to say that we may not find evidence on examination of the neck that the goiter, if present, is toxic in all likelihood, as has been outlined in the previous discussion. Yet the local signs which, on examination of the goiter itself, suggest toxicity are almost entirely circulatory phenomena, thrills and bruits over the superior and inferior thyroid arteries, expansile pulsation of the neck and abnormalities of the filling of the superficial jugulars. These may be equivocal and some of them, particularly the carotid and jugular phenomena, are not specific for thyrotoxicosis. They are, finally, characteristic only of acute or refractory hyperthyroidism of a fairly high grade and may not be present at all in relative remissions of the functional disorder. The generalization is a fair one, therefore, that one should make the effort to estimate thyroid function first without reference to neck findings, then to correlate the two sets of data. The more comprehensive is one's experience with thyrotoxicosis, the more rarely will appear apparent paradoxes between local and systemic findings.

The diagnosis of hypothyroidism and myxedema are outside the scope of this discussion since they are not, in themselves, indications for thyroidectomy as is, by and large, hyperthyroidism. While we are not concerned here with the indications for thyroidectomy, it may clarify our dismissal of the subject of hypothyroidism from further discussion to say that only certain types of goiters (Riedel's struma, questionable carcinoma, adenomatous and the large colloid goiters) seen with hypothyroidism or with normal gland function may properly be considered operable; whereas the goiter associated with thyrotoxicosis is nearly always properly to be considered as a surgical problem at one time or another regardless of its pathological classification. More simply, in decreased or normal function of the gland the pathological classification of the goiter or associated mechanical and cosmetic features constitute the indications for or against thyroidectomy; in thyrotoxicosis, the abnormal function itself constitutes the indication.

Thus we come to the problems involved in the recognition of thyrotoxicosis. In no field of medicine has more gratuitous nonsense been preached by individuals unfamiliar at first hand with the course of the patient throughout the disease in its varying development and progress. Thyrotoxicosis does not differ from many other disorders in requiring a fairly concentrated experience with its manifestations, the opportunity for prolonged observation of patients, preferably in more than one generation of the family of these individuals, and leisure for careful consideration of the rapidly shifting phenomena of the disease before the thoughtful observer will have developed a mature and comprehensive view of it. Many of the factors militating against a clearer understanding of the disease are to be blamed on the faulty observations and misconceptions of a previous generation and these are perpetuated as myths in current thinking on the subject; others are being introduced by members of the writer's generation in

medicine, usually in the form of ill digested bits of experimental efforts whose results (!) have been translated into terms of clinical medicine by observers profoundly unfamiliar with thyrotoxic patients. There is much that is obscure in the origins of hyperthyroidism and in its disturbances of intermediate metabolism, but the confusion and ignorance among physicians of the phenomena that characterize the clinical course of the disease are largely the result of poor clinical and didactic teaching in our medical schools and the number of articles accepted for publication by editors who are apparently unable to evaluate them critically. Thyrotoxicosis in its clinical manifestations is not nearly so mysterious as we have made it.

An intelligent evaluation<sup>1</sup> of the thyroid status of the patient suspected of having hyperthyroidism can only be made with regularity if the examiner is familiar with the *spontaneous course* of the disease and with the degree to which it may also have been altered by treatment previous to his examination. Fundamentally, the spontaneous course of hyperthyroidism, it cannot be said often enough, is by remissions and relapses. Such a cyclic course is most pronounced in the patients with the diffuse hyperplastic goiter most often associated with exophthalmos, somewhat less striking in the patient with multinodular toxic goiter and hardly noticeable in the patient with the solitary, toxic adenoma. In addition to this conditioning of the severity of relapses and of recovery toward a baseline of health (normal thyroid functional status) in the remissions by the *pathological type* of the goiter, there is an important modification of the cyclic characteristic with the passage of time, for the gradual downhill course over prolonged periods, in terms of years, tends in general to produce a chronic, refractory type of hyperthyroidism at the more severe levels of the disease, with only transient and minor phases of improvement. Whether the essentially cyclic nature of the disease is due to a recurring stimulus whose intensity varies



or whether it consists of a cyclic response by the gland to a constant stimulus (if, as seems likely, stimulation from a source outside the thyroid is essential to the development and maintenance of hyperthyroidism) is beyond the scope of this discussion. One may, therefore, count on the occurrence of fairly complete remissions, *given time*, early in the course of the disease but, on the other hand, should expect only relatively minor improvement in the patient much farther along the road regardless of how long one waits. We take advantage of these facts in deciding when to perform thyroidectomy in the individual case and in choosing between one-stage and two-stage thyroidectomy.

A most striking illustration of this is the patient of the type, seen occasionally by every surgeon of considerable experience in this field, who will be intensely thyrotoxic for a period of several weeks after coming under treatment, in whom operation is quite properly deferred and who returns after several months with not merely a return to normal thyroid status but with myxedema. It was the observation of such cases that led us to abandon preliminary ligation<sup>2</sup> of the superior thyroid arteries as being not only dangerous but of no therapeutic merit, in 1931. We learned to expect quite as rapid (or as slow) improvement in patients deferred over the same periods of time without ligation and obviated the mortality of 7 per cent which ligation carried in our hands between 1925 and 1931. We have records of patients so deferred whose basal metabolic rates have fallen below zero after a lapse of months of continuous treatment. One frequently sees, of course, the patient at a time when his thyroid function is normal, as judged by all tests not involving the performance of work by the patient, but who has been clearly shown to have been moderately thyrotoxic at a previous date by a thoroughly competent observer. A carefully taken history, then, will trace the development of the disease and will mark the occurrence of such episodes previous to the

time of examination and will, taken in conjunction with physical and laboratory data, permit one to chart the patient's position with considerable accuracy on the individual course his disorder has taken. One is also enabled to predict with fair accuracy the probable future course of the patient, if left to his own devices, but the physician who values his reputation as a prophet will bear in mind that the *duration* of remissions and relapses is uncertain. The writer is personally familiar with two obdurate individuals who were gravely informed by a surgeon of wide reputation during episodes of severe thyrotoxicosis over ten years ago that they would be dead within six months unless they consented to operation. Their precarious maintenance of chronically impaired health justifies them, in their own minds, as advertising their would-be benefactor as an alarmist and "radical."

The spontaneous course of thyrotoxicosis will be modified, *but not essentially altered*, by treatment in varying degrees as the ideal combination of rest, sedatives and iodine is, or is not, achieved. A detailed account of previous treatment is essential to the interpretation of the history and the current physical and laboratory findings. It is a permissible digression at this point to say that everyone with a professed opinion on hyperthyroidism should be familiar with the work of Means<sup>3</sup> and his co-workers on the relative effects of the continuous administration of iodine and its alternating administration and withdrawal in "courses" which is unfortunately still fashionable. Their publications are the standard work on the subject, in the writer's opinion, and bear out most graphically our own observations which have led us since 1930 to administer iodine continuously to thyrotoxic patients from the time of their first examination until some weeks after operation. We fully share Means' view that iodine does not itself induce refractoriness to its own effects but that the patient who is getting into a relapse in the more severe grades of

thyrotoxicosis is *relatively* more refractory than to iodine, as to all other measures, than he is at a time when he is starting on a spontaneous remission.

One approaches the hyperthyroid patient, then, with the view that the disease is cyclic in character and that the point at which the patient finds himself on his own course at a given time is conditioned not only by the type of goiter involved but by the duration of the disease and by such previous treatment as he may recently have had. It is not our purpose to detail here the signs and symptoms of thyrotoxicosis, but to recall a plan<sup>1</sup> for the recognition and evaluation of the acutely thyrotoxic individual and to point out the necessity for prompt institution of treatment for these individuals who are generally getting worse at the time of first examination (or they would not request it) and are often on the verge of crisis. The manifestations of thyrotoxicosis are somewhat erratic at times in that expression of the disease may be much more pronounced in one organ-system than in others and it is axiomatic with us that the patient may get worse (or improve) in different respects at different rates. The more *inclusive*, therefore, the system of assaying the signs of severity of the disease, the less apt is one to overlook a single important clue to impending crisis when all other signs are reasonably satisfactory. This is equally important in estimating the risk of operation at any given time and extremes of physiologic derangement in any of the respects outlined below constitute, in fact, absolute contraindication to operation at such a time. The validity of these views has been proclaimed by Willard Bartlett, Sr. for many years and the general trend to individualization<sup>4</sup> in treatment of thyrotoxic patients, current during the author's participation in surgical practice, has been importantly shaped by his efforts.

#### PRIMARY CRITERIA

1. *Circulatory.* The more extreme grades of tachycardia, with either normal

cardiac mechanism or auricular fibrillation, are warning signs. The writer has seen only two instances in which cardiac decompensation has occurred with *regular* rhythm, one of them a woman of eighty-four with severe co-existent hypertension, the other a diabetic patient of sixty-five, also a hypertensive individual. Almost invariably, therefore, auricular fibrillation will appear before decompensation occurs and, in fibrillators, the *first sign* of a break in compensation is the appearance of a pulse deficit; its presence or absence must be definitely established in all fibrillators. Decompensation does not occur, in the belief of the writer, in thyrotoxic patients who have not another disease of the circulatory system and he has encountered but one case in a patient under forty years of age. In a series of decompensated patients seen over one five-year period, the average age of these individuals was forty-eight years in comparison with the average age of thirty-five years for all thyrotoxic patients admitted during the same time. Certainly, the circulatory apparatus of the person past fifty years withstands the added burden of hyperthyroidism much more poorly than does that of the younger person. By far the commonest co-existent circulatory disease in our own patients who become decompensated is hypertension. Moreover, the overwhelming majority of our patients admitted with decompensation are severely thyrotoxic and have become decompensated in an exacerbation of thyrotoxicosis. Their basal metabolic rates, determined after the restoration of compensation, have usually fallen between plus 40 and plus 65, which is high indeed for patients in this age group.

The existence of low concentration of protein in the blood plasma, often with a reversal of the albumin-globulin ratio, was described by Shirer<sup>5</sup> in 1932 and has been confirmed by Bartels,<sup>6</sup> Brown and McCray<sup>7</sup> and in unpublished data of the writer. It was attributed by Shirer to incomplete assimilation of ingested protein from the small intestine which is known to show

increased mobility and rapid emptying in thyrotoxicosis. Bartels attributes it also to reduced production of protein by the liver, the principle source of plasma protein. The writer<sup>8</sup> has postulated a loss from the blood due to capillary damage caused by the severe acidosis<sup>9</sup> recently shown to be characteristic of the disease. In any case with edema, therefore, as pointed out by Shirer (whose paper has come to the writer's attention only during the preparation of this article), decreased concentration of the proteins of the serum or plasma should be sought as another possible etiological agent beside myocardial insufficiency.

It is worth mentioning that no decision can be made with certainty as to the presence or absence of hypertension in patients who are first seen with decompensation until after thyroidectomy has been performed and normal thyroid balance regained. It is similarly true that the diagnosis of diabetes mellitus in the glycosuric patient with moderate grades of hyperglycemia cannot be proved or disproved in the presence of severe hyperthyroidism. But the existence of two diseases affecting the circulatory apparatus must always be regarded as the probability in the early evaluation of the decompensated patient with toxic goiter; and the complicating diseases, in order of their frequency in the writer's experience, are hypertensive heart disease, arteriosclerosis (out of proportion to the patient's age) without hypertension and valvular lesions of the heart. Decompensation constitutes an absolute contraindication to operation, as long as it persists.

2. *Nutritional Status.* The patient who is losing weight at a rapid rate in an acute phase of the disease may easily get into a precarious situation. One sees occasional cases in which a gain in weight to a new high level for the patient occurs at the onset of the disease. Such patients, to the best of the writer's knowledge, have not been studied critically. The obvious possibilities are two: their caloric intake is

sufficiently in excess of their energy requirement that fat is actually stored or they are having gradual storage of water, presumably in association with depletion of plasma proteins, in clinically undetectable amounts.

The writer wishes to record here an observation that has intrigued him for years and of whose validity he is confident. This is a rather rapid gain in weight previous to the onset of symptoms of hyperthyroidism as being so frequent a finding in a carefully taken weight history as to be almost characteristic. While at this high weight level, briefly maintained, the symptoms of thyrotoxicosis occur and the traditionally observed loss of weight ensues. It is our belief that the original gain in weight above the patient's previous average is a part of the disease process that eventuates as thyrotoxicosis. We believe, furthermore, that statistical study will show that the incidence of obesity in persons who develop hyperthyroidism is importantly higher than that for the general population. Herz and Means<sup>10</sup> have commented on the onset of hyperthyroid symptoms following profound losses of weight, however induced, but they have not, apparently, been impressed with the occurrence in their patients either of a preceding rapid gain in weight or of the significance of obesity of long standing. As a matter of fact, weight losses should be reported and evaluated not only in terms of pounds or kilograms, but in *percentage of body weight*. Thus, we can say offhand that the patient who has lost over 25 per cent of body weight as a result of disease, regardless of its nature, is generally in a precarious situation and this is particularly true in hyperthyroidism. A large percentage of our two-stage thyroidectomies are performed on patients in whom such weight losses have occurred. We regard a weight loss at the rate of more than one-half pound per day under hospital treatment as being an absolute contraindication to operation.

3. *The Nervous System.* One is tempted to think that only lack of acquaintance at first hand with the general public could lead to the attribution of such various vagaries of behavior as have been blamed on thyrotoxicosis. Hyperthyroid individuals are not the only ones who behave eccentrically, have poor judgment and emotional instability and are restless and irritable. Thyrotoxicosis has even been discussed seriously as being itself a psychoneurosis and the onset of hyperthyroidism is frequently attributed to worry. The writer would cut through all such discussion by stating that intimate and prolonged familiarity with thyrotoxic patients, their parents and their children, convinces him that thyrotoxicosis merely accentuates the normal characteristics of the individual. In other words, hyperthyroidism makes "nervous" persons more "nervous." The not infrequent occurrence of thyrotoxicosis in a usually calm, emotionally mature individual does not turn that patient into a flighty, irresponsible person. The late appearance of such patients has been graphically described by Lahey<sup>11</sup> in his striking term of "apathetic" hyperthyroidism; but I believe that one underestimates Dr. Lahey's mastery of his subject if one takes his characterization to mean that behind the patient's "dead pan" face, overstimulation and visceral intoxication are not proceeding just as in less phlegmatic individuals. Certainly, in our view, the presence of emotional immaturity, outbursts and irresponsibility raises the serious probability that there are two disorders present, only one of which is hyperthyroidism, affecting the behavior of the patient. The proper time for exact differential diagnosis is *previous* to operation and thyroidectomy undertaken as a sort of therapeutic test of the patient's psychic status is apt to have shocking repercussions. If more exact differential diagnoses were carried out on these individuals, there would be fewer tales among laymen of patients who have "lost their minds" following thyroidectomy. In the thyrotoxic

patient, the presence or recent occurrence of *acute thyrotoxic psychosis* is closely associated with thyroid crisis and constitutes an absolute contraindication to operation. The importance of cerebral edema in crisis has recently been pointed out by the writer.<sup>12</sup>

4. *Excretory Systems.* It is most uncommon to see abnormalities of renal function as a result of hyperthyroidism. But the gastrointestinal tract and the skin give important indications of the severity of the disease at times. Increased frequency of stool is rather characteristic of our own patients and the occurrence of vomiting, diarrhea or of four to six stools (even though formed) per day in a previously constipated individual may herald the approach of crisis. While it is inexact in terms of physiologic and biochemical derangements, it is clinically useful to think of the brain, the circulatory apparatus and the gastrointestinal tract as all tending to show in varying degree evidence of stimulation by toxic goiter. When dissipation of body heat lags behind its production under conditions of moderate environmental temperatures, gross sweating occurs as the insensible perspiration<sup>13</sup> increases with rising metabolism. The author, as surgical house officer under Dr. Coller, used to hear him say that thyrotoxic patients never got pneumonia. This is a very fair generalization, barring, of course, the terminal bronchopneumonias of crisis. We recall having seen but one postoperative pneumonia; it was associated with lobular atelectasis and aspiration of ingested water associated with injury of the inferior laryngeal nerve. The presence of vomiting, diarrhea and excessive sweating are absolute contraindications to operation.

5. *The Basal Metabolic Rate.* The level of basal metabolism in thyrotoxicosis is always of interest to us. Its use and limitations in differential diagnosis will be discussed later. In serious grades of hyperthyroidism its tendency to rise, to remain stationary, or to fall during periods of close observation is of more consequence than

the actual levels through which its variations are measured. A rising metabolism is an absolute contraindication to operation.

6. *Duration of Voluntary Apnea (D.V.A.): the Breathholding Test.* This test was first applied to thyrotoxic patients and its usefulness perceived by Willard Bartlett, Sr., in 1924, and the writer has had the opportunity of developing it,<sup>14</sup> modifying the technic to its present form, standardizing the interpretation of the results<sup>15</sup> and finding in acidosis the probable biochemical explanation<sup>8</sup> for its behavior. No detailed consideration of the technic of the test will be given here. We regard it as being the most useful single method of estimating the severity of thyrotoxicosis in a given situation, for any of the more advanced signs of acuity, as elaborated in the preceding paragraphs, are reflected in the ability to hold the breath. Its *inclusiveness* is of the utmost value to us, taken in conjunction with other clinical and laboratory data, in deciding when operation is safe at all and whether a one-stage or two-stage thyroidectomy will be done.

Of the various laboratory procedures other than the estimation of basal metabolic rate, only mention of the determination of plasma proteins (already alluded to) and of the various tests of liver function will be made, since their proper sphere of usefulness is not in the diagnosis of hyperthyroidism, but in its treatment. Blood cholesterol and amylase will be referred to later.

#### DIFFERENTIAL DIAGNOSIS OF THYROTOXICOSIS

There is ordinarily little difficulty in the recognition of acute or severe hyperthyroidism if the characteristics of its more serious stages, as set forth above, are part of one's organized knowledge. The text books classically list pulmonary tuberculosis, cancer and diabetes as being the diseases from which it must be differentiated, yet cachexia, common to the advanced phases in neglected cases of all of

these disorders, is the only common denominator among them. One must be aware that there is no law against the thyrotoxic patient also having another disease. We see the co-existence of toxic goiter and, variously, diabetes, carcinoma (especially of the female breast), psychoneuroses and hypertensive heart disease not infrequently, as noted previously, and one will always have to be prepared for such findings in examining patients who have reached middle age. Yet it is a tribute to the success of the concerted attack on tuberculosis in the past two decades that the writer has not seen (or has not recognized) the co-existence of thyrotoxicosis and active pulmonary tuberculosis in a single instance in private practice. Let us leave the discussion of the situation in which the patient has two diseases, one of them a toxic goiter, only with the warning that it "can happen," that a complete diagnosis should be made before thyroidectomy is performed and that the actual existence of diabetes or hypertension in the thyrotoxic patient may sometimes be demonstrated with *certainly* only after restoration of normal thyroid status has been achieved, however strong the previous suspicion of their presence.

The eye signs of hyperthyroidism have not previously been discussed because of the growing conviction of the writer that they are almost irrelevant to the diagnosis. This statement wants qualification: (1) If the examiner does not use an exophthalmometer, the simplest instrument being that devised by Luedde,<sup>16</sup> he is able to recognize exophthalmos only of the most severe grades and is unable to measure the considerable variations of individual patients that occur during their clinical course; (2) measurable grades of exophthalmos may be seen with the microscopic picture of hyperplasia in the thyroid regardless of the various gross pathological characteristics of the gland (diffuse or nodular enlargement); (3) it is the present impression of the writer, based on unpublished data, that lid signs are more con-

stantly associated with disorders of thyroid function than are measurable grades of exophthalmos; (4) severe exophthalmos is often associated with hypothyroidism, rather than with hyperthyroidism, and is reversible, in the early phases, by thyroid feeding;<sup>17</sup> (5) the writer believes that exophthalmos, lid-lag and extra-orbital muscle palsies in patients with disorders of thyroid function will eventually be proved to be due to wholly indirect effects of the latter. The limitations of space preclude any consideration of the evidence for these statements. The fact is, practically, that positive eye signs are not *alone* pathognomic of thyrotoxicosis and may be present with normal thyroid function or with hypothyroidism. That they are apt to be present in diffuse hyperplastic goiter with thyrotoxicosis is unarguable.

The commonest confusion in the minds of physicians in general arises in the differential diagnosis of questionable thyrotoxicosis from (1) psychoneurotic states and (2) states involving pluriglandular deficiencies. In both of these situations the patient with a goiter is in serious danger of thyroidectomy, though the goiter may be only an innocent bystander. Where no such complicating conditions are present, the recognition of the thyrotoxic patient, if seen first *during a remission*, offers problems of its own. Some of the characteristics of remissions, spontaneous or induced, have already been considered in the discussion of the spontaneous course of thyrotoxicosis. If the patient has recently taken iodine, the decision as to whether the patient has previously been hyperthyroid, and is now in a remission, or has never been thyrotoxic at all, can be puzzling indeed. Obviously, if the patient has in fact been toxic, the remission is the ideal time to perform thyroidectomy and one will be secure in the knowledge that important subjective benefit will ensue. On the other hand, if the symptoms, however alleviated during brief treatment (iodine or otherwise), are due to some disorder other than hyperthyroidism, the patient stands an

excellent chance of being made worse by operation. It is too much to hope that the status quo will be maintained after any major operation.

Allusion has been made repeatedly to the fact that considerable or complete remission may be expected with the passage of time, regardless of treatment, in the early cycles of thyrotoxicosis, particularly when the goiter is not nodular. In such cases, all objective findings made under resting conditions, including basal metabolic rates, may be well within normal limits which are elastic at best. We have proposed an original method for recognition of such patients and we are confident that *the response of the circulation to measured exertion* is of great value in the clarification of this situation. The writer has recorded several hundred such tests and finds quite characteristic patterns<sup>18</sup> in the results.

*Technique.* Under resting (not necessarily basal) conditions, the pulse rate and pulse pressure are estimated repeatedly until no further diminution in the activity of the circulation occurs. These are recorded as "resting" values. The patient then hops twenty times on each foot in a period of about twenty-five seconds and resumes the sitting posture. The pulse rate and pulse pressure are then determined immediately and at intervals of one minute thereafter for the first five minutes of the recovery phase.

One sees three characteristic responses in the patients under consideration: (1) Patients with nontoxic goiter, whether their thyroid function is normal or subnormal, respond by a moderate, immediate increase in both pulse rate and pulse pressure with recovery to resting values within two, or at most three, minutes. (2) Hyperthyroid patients in remission (even though the basal metabolism is below zero, as in numerous cases of the writer) show an acceleration of pulse rate or a very large increase in pulse pressure, or both, immediately after exertion and a *failure to return to resting levels* in one or both phases (especially the pulse pressure) within three

minutes. (3) Patients whose thyroid function has not been abnormal, but who have psychoneuroses (especially the anxiety states) characterized by circulatory symptoms, show *little or no increase of pulse pressure* in response to exertion and it may actually fall below resting levels immediately after exertion or during recovery; pulse rate has always returned to resting values within three minutes in these patients.

Such objective evidence as to thyroid function from the response to work is of great value, taken in conjunction with subjective data (to be discussed) in trying to decide whether the goitrous patient has a low grade hyperthyroidism in remission, or has normal thyroid function (or hypothyroidism) plus a "living problem" which has eventuated in a neurosis that more or less closely simulates hyperthyroidism. The regular performance of the exercise test decreases considerably the number of therapeutic tests with iodine otherwise necessary and permits one to carry out such therapeutic tests with at least a more enlightened attitude. If therapeutic tests are to be done, their value is greatly enhanced (in that positive or negative results can be freed from the taint of suggestive therapy) if *serial* estimations of plasma cholesterol and amylase concentrations can also be obtained. The principal deviation of cholesterol (elevation) is most regularly observed in hypothyroidism and the decided usefulness of knowledge of its behavior in this situation has been emphasized by Hurxthal.<sup>19</sup> The variations of plasma amylase are complementary, its greatest deviation from normal (depression) in hyperthyroidism having been originally described<sup>20</sup> by the writer. Single estimations of either of these substances are not of great use in the differential diagnosis of the particular problem with which we are presently concerned, their ranges of normal values being considerable, yet their shifts, even though these be within the ranges of normal, in response to specific therapy, are most suggestive in the

evaluation of thyroid function by therapeutic tests. They have the merit of not being subject to the numerous upsetting influences that are reflected in the level of "basal" metabolic rate.

It is to be hoped that the reader will not assume from the immediately preceding paragraphs that in the case of the patient with an apparently innocent goiter and complaints roughly simulating hyperthyroidism, inexplicable on any basis of organic disease, it is necessary always to carry out the methods of objective examination detailed in addition to the usual routine of careful, comprehensive physical and laboratory study before arriving at a definite conclusion. On the contrary, these accessory methods are not usually necessary but they will give information of decided value in those occasional cases in which the skillful physician finds himself most skeptical of the validity of his own conclusions. The performance of such tests is in itself a measure that will often win the respect and confidence of a patient whose outstanding characteristic is loss of self-confidence and who has already been examined by the usual methods by others with inconclusive results. Certainly, the additional understanding of these basic deviations of physiologic and biochemical characteristics engenders in the physician a confidence in the direction in which he is going that is easily communicated to the patient who may have been distressed by attitudes of bland reserve previously encountered.

No group of patients exists whose problem is more challenging to one interested in man's combat with his environment than that composed of the individuals who are currently classed as being "functional" cases. This term is probably to be taken as evidence of our present inability to measure the organic terms that constitute inferiority of physical make-up, the microscopic or physicochemical inadequacies that result in the scale being tipped toward a breaking down of the sense of well-being under the stress of problems of living. Much can be

learned from an organized analysis of what the symptoms mean to the patient, even though the physician has not the intuitive gift of sensing frustration, fear and hopelessness in the person so afflicted. The possession of what Hugh Cabot has termed "a low threshold of suspicion" is a priceless asset if one is to recognize such characteristics in the patient, realize the *validity* of symptoms arising from problems inseparable from the business of living and translate them into terms of treatment intelligible to one who is bewildered enough when he comes to the physician for help. The analysis of such subjective symptoms has been detailed elsewhere<sup>18</sup> and their differentiation from the symptoms of hyperthyroidism, which they may more or less closely simulate, is not ordinarily difficult. Such an evaluation of symptoms should precede physical and laboratory examinations. It will not be obtained, except by good luck, hurriedly, or by the inexperienced, or by "hired hands." Inquiry should be made into the following ten points though the patient may not volunteer information about some of them while being very voluble about others:

1. *Nervousness.* Pronounced emotional coloring and frequent presence of phobias characterize the neurotic patient's complaint. The effect of such feelings is to alter the pattern of behavior much more than in the case of the thyrotoxic individual, who tends to keep on at his usual tasks, whereas the neurotic typically withdraws more and more from participation in the ordinary routine of living.

2. *Heart Consciousness.* A variety of expressions of concern over the behavior of the circulatory apparatus is exemplified by the frequent complaint that the heart cannot be felt to beat at all, or that it is going to stop altogether; this may alternate with a sensation of overactivity, of palpitation or of precordial pain. The association with exacerbations of emotional stress is more noticeable than with exertion, distraction of attention and relief often being obtained by even purposeless activity.

3. *Loss of Weight.* The coincidence with either loss of appetite or discomfort after eating small amounts is constant; the common result is diminished food intake. We have seen more extreme grades of emaciation with anorexia nervosa than with thyrotoxicosis.

4. *Shortness of Breath.* This is to be sharply differentiated from dyspnea on exertion though this latter may also be present. It consists of sighing respiration, occasional overventilation with tetany, or a "smothering" sensation relieved by changing position and, especially, by access to moving air.

5. *Neck Sensations.* These are uncommon in toxic goiter or in other goiters in which decided evidence of interference with the airway is lacking. A sense of constriction, "tightness" in the neck and choking sensation, especially on excitement, are typical.

6. *Weakness.* This usually is present on arising in the morning and is accentuated by the contemplation of a task, rather than by its accomplishment. It leads to avoidance, not only of physical work, but also of social contacts and the effort implied therein.

7. *Inability to Sleep.* Difficulty in getting to sleep associated with worrying in bed and light sleeping are common, as is the feeling of wakening completely unrefreshed. All statements as to the duration of sleep are most unreliable.

8. *Abnormal Temperature Sensations.* While the thyrotoxic patient is notoriously intolerant of heat and the hypothyroid patient of cold, the neurotic individual is apt to be distressed by both extremes of temperature. Perspiration from cool extremities is characteristic, as is profuse axillary or facial sweating, particularly on excitement.

9. *Digestive Disorders.* A multiplicity of complaints is again common here. Flatulence, dyspepsia after a few mouthfuls, the most impressive consciousness of peristalsis and concern over the daily stool are observed. Various phases of "colitis" with



mucus in the stool are occasionally present. Extremes of diarrhea or of constipation and their accompanying phenomena may quite overshadow the circulatory or nervous complaints as the history is developed.

10. *Menstrual Disturbances.* While hyperthyroidism generally tends toward diminution in the amount of flow and may occasionally be accompanied by the suppression of the menses, the history of decided irregularity, periods of amenorrhea, excessive flow and late appearance of the menarche should prompt the suspicion that an endocrine imbalance may be responsible for at least some portion of the sympathetic instability of certain of these patients. Menopausal symptoms may also be confusing.

Above all, the impact of the personalities of these individuals should be one that enables the examining physician to put together the threads outlined in this brief sketch of the characteristics of their symptoms and to observe how they weave a pattern of interference with normal duties, withdrawal from the business of living into a constantly diminishing circle that yet has, typically, brief moments of a sense of well-being quite unlike the rhythm of hyperthyroid fluctuations. These latter are measured in weeks or months, rather than in hours or days. These unhappy patients, moreover, *complain* of their health. The thyrotoxic patient is so apt to be intoxicated and overstimulated that he is almost unaware of fatigue and tends to minimize even serious disability.

#### EVALUATION OF THE BASAL STATE

Finally, a brief consideration of the estimation of basal metabolic rate is appropriate for it is most difficult to determine accurately in the patients in whom it is most needed. The important errors, as far as the diagnosis of hyperthyroidism and its differential diagnosis are concerned, are not made at levels above, say, plus 20 per cent, but between the levels of zero and plus 20. The ideal state which we wish to induce at

the time of the test is, after all, that obtained just after waking and before arising in the morning. It is fruitless to hope to reproduce such a state after 9 A.M. in a person who has been awake since 6 A.M., who has slept badly, who has assumed some of the household responsibilities before proceeding to the laboratory, who has been a lengthy trip through metropolitan traffic (especially in a crowded public conveyance) or who is burdened emotionally at the time of the test. The means whereby we strive to obviate such upsetting factors are not to our point here, which is to recognize by objective methods that we either have or have not achieved a truly basal state. This evaluation of the "basality," or lack of it, is all important if one is to interpret wisely the rate estimated from the oxygen consumption under those particular circumstances. If the physician does not have the data on which to review each test critically, the estimation of basal metabolic rate will be confusing or misleading about as often as it is helpful in evaluation of the thyroid status.

We have been gathering such data since 1938 and the plan to be outlined not only has merit but is the only one known to us which gives the desired information and does not force us to fall back on clinical judgment alone when the reported metabolic rate is at variance with our expectation. It consists merely of a comparison of the pulse rate and pulse pressure determined under (1) frankly nonbasal but *resting* conditions in the office with (2) similar data recorded, usually on the day immediately preceding or following, under allegedly basal conditions at the time of the estimation of metabolic rate. The circulation, as judged by the pulse rate and pulse pressure, should show measurable slowing under conditions purporting to be basal. Those metabolic rates obtained in patients with normal thyroid function, hypothyroidism, or hyperthyroidism which are most readily acceptable in view of clinical data have uniformly been accompanied by such decrease in both pulse rate and pulse

pressure. We have been fully confirmed in our rejection of such other tests in which significant diminution of pulse rate and pulse pressure did not occur by clinical data, other laboratory procedures and repetition of the tests. On several occasions on which we have rejected the metabolic rate as not being basal, we have found the pulse rate and pulse pressure to be practically the same under resting conditions after luncheon on the day of the test and have repeated the metabolism determination then and there, finding approximately the same oxygen consumption in the middle of the afternoon as under the allegedly basal conditions of the morning. We believe that during the test itself periodic recording of the pulse rate alone is sufficient to indicate the occurrence of discomfort, nervousness, or fatigue which has not been present at its beginning; and more than minor variations of pulse rate are, of course, sufficient to cause us to view the result with suspicion. We are satisfied that with these circulatory criteria we can at least evaluate the degree to which we have achieved, or have failed to achieve, an approximation of the basal state and to discount or to reject intelligently those reports of the metabolic rate obtained when considerable slowing of the circulation has not occurred. Such a routine requires patience and attention to detail,

but does not differ in so doing from all other worth while methods, clinical or laboratory, which are useful in the evaluation of the thyroid status.

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# DIAGNOSIS IN ACUTE PELVIC CONDITIONS

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**D**IFFERENTIAL diagnosis of acute pelvic conditions, as, indeed, all diagnosis, is dependent upon evaluation of minute details of the patient's own story and on performing an examination which is sufficient to detect or rule out the various probabilities.

At the expense of appearing trite, it seems not out of order to emphasize these requisites. The clinician who develops his own story from direct conversation with the patient, giving particular attention to the sequence of events and the manner in which the history is related, has an infinitely better chance of arriving at a correct diagnosis than he who depends on a history recorded by another person. It is extremely difficult, if not impossible, to convey the fine shades of difference of meaning which the same written words may imply. In this connection also should be mentioned the importance of giving full credence to the patient's story, at least, until it is proved to be false. More diagnoses are missed by discounting some apparently minor statement or flatly refusing to accept the patient's story than by the clinician's being deliberately misled. The author will not soon forget that as a student he missed the opportunity of diagnosing a spontaneously developing gastrocolic fistula because he refused to accept a Pullman porter's statement that fifteen minutes after eating whole cherries, he would pass the seeds by bowel.

The examination, both clinical and laboratory, must be comprehensive enough to include an opportunity to detect the likely cause of trouble. Even the relatively inexperienced clinician is able to interpret the findings of routine examinations. Most of our errors are attributable to failure to make certain examinations and tests rather

than to our inability to interpret those which are performed. This point is well illustrated by the not infrequent error of mistaking a right basal pneumonia for acute appendicitis because of failure to examine the chest with this possibility in mind.

Because of the necessary limitation of this presentation it is impossible to discuss in detail every cause of pelvic pain in women. Only the more frequent conditions will be considered and only the most significant diagnostic points will be developed. The author disavows any claim of presenting new or original thoughts on this subject but it is hoped that a review of some of the well established diagnostic criteria may be of some benefit.

For the sake of clarity, the chief diagnostic points of each of the major causes of pelvic pain have been tabulated, and the table is followed by a brief discussion of each condition. It seems wholly unnecessary to state that no single sign or symptom in these lists is pathognomonic of any condition and that only by taking the clinical picture as a whole can one reach a sound decision.

## ACUTE PELVIC INFLAMMATION

### Chief Diagnostic Points

1. Follows some provocative cause:
  - (a) Menstruation
  - (b) Abortion
  - (c) Childbirth
  - (d) Instrumentation
  - (e) Excesses (sexual and alcoholic)
2. Bilateral pain
3. Tenderness greatest near Poupert's ligament
4. Fever relatively high (101 to 103°F.)
5. Leucocytes relatively high
6. Sedimentation rate very rapid

7. Evidence of infection in lower genital tract
8. Bilateral pelvic masses

In the absence of some provocative cause for its ascent, it is well known that gonococcal infection of the lower genital tract tends to remain below the level of the internal cervical os. Of such causes, menstruation is by far the most frequent as is evidenced by the fact that most patients with acute tubal inflammation date the acute onset near the end of a menstrual period. In most of the remainder, one or another of the listed provocative causes can be elicited.

Because of the wider area of involvement in gonococcal pelvic inflammatory disease, the fever tends to be high, the leucocyte count high and the sedimentation rate rapid as compared to these findings in acute appendicitis. The bilateral distribution of pain, if present, renders differentiation relatively easier.

The patient who presents the above picture should be examined for evidences of gonococcal infection of the lower genital tract, giving particular attention to Skene's and Bartholin's glands as well as the cervix. As it is almost, if not quite impossible to reach any decision relative to these structures with the patient in bed, the necessity of examining patients on a proper table with adequate light is quite evident.

While evidence of gonococcal infection of the lower genital tract is almost conclusive proof of pelvic inflammatory disease, one must remember that such evidence does not completely eliminate the existence of some other condition which may require immediate operative treatment.

Palpation of tender bilateral adnexal masses in a patient who presents a typical picture leaves no doubt of the existence of pelvic inflammatory disease. In many of the very early cases, however, the inflammatory process is still in the catarrhal stage and in these the only positive findings may be bilateral adnexal tenderness, and the production of sharply increased pain on lateral motion of the cervix.

## ACUTE APPENDICITIS

### Chief Diagnostic Points

1. Occurs unrelated to periods
2. Often provoked by intestinal upset
3. Typical sequence of symptoms:
  - (a) Generalized pain
  - (b) Localization of pain
  - (c) Nausea
  - (d) Vomiting
4. Tenderness unilateral, localized at McBurney's point
5. Low fever (99 to 100°F.)
6. Relatively lower leucocyte count than in pelvic inflammatory disease
7. Relatively slower sedimentation rate

While the gynecologist readily admits that acute appendicitis is not always a pelvic condition, the frequency of its mistaken diagnosis in patients who do have pelvic lesions, leaves it in the controversial territory between the gynecologist and the general surgeon.

The history will reveal the classical sequence of the symptoms in most cases of appendicitis. Relationship to the usual provocative causes of pelvic inflammatory disease cannot usually be established. Less elevation of temperature and of the leucocyte count, the relatively slow sedimentation rate and typical localization of the pain and tenderness are invaluable points in differentiating appendicitis from inflammatory disease. The presence of fever and the classic sequence of symptoms along with an entirely negative pelvic examination point to appendicitis as opposed to hemorrhage from a ruptured Graafian follicle or corpus luteum.

## OOPHORRHAGIA

### Chief Diagnostic Points

1. Definite relationship to menstrual cycle
  - (a) Midway—follicle
  - (b) One week before—corpus luteum
2. Pain is low
3. Shock and severe hemorrhage are rare
4. Nausea and vomiting rare

5. Fever—little if any
6. Leucocytes normal or only slightly increased
7. Sedimentation rate is normal
8. Friedman test negative

Oophorrhagia, a term recently introduced by Costallo to designate bleeding from the ruptured Graafian follicle or the corpus luteum, is receiving a deservedly increasing amount of attention. The occurrence of low pelvic pain, not often severe, midway between menstrual periods with little other symptomatology, strongly suggests bleeding from a ruptured follicle. A similar clinical picture developing a week or ten days before the expected date of menstruation indicates the probability of rupture of the corpus luteum.

Although the bleeding into the peritoneal cavity may occasionally be profuse, rarely is it sufficient to give rise to constitutional signs of hemorrhage. There is, as a rule, little if any rise of temperature; the leucocyte count if at all elevated, is only slightly so.

The absence of typical signs and symptoms of the more frequent lesions, together with the characteristic relationship to the menstrual cycle constitute important diagnostic aids. Differentiation of oophorrhagia from ruptured ectopic pregnancy is indicated by absence of the history and the objective findings of pregnancy, by a less critical clinical picture, and by a negative prolan test for pregnancy.

#### ECTOPIC PREGNANCY

##### Chief Diagnostic Points

1. Occurs usually after missed period
2. Onset is sudden
3. Pain is severe
4. Shock often supervenes
5. Constitutional signs of hemorrhage
6. Signs on examination suggest pregnancy
7. Extreme tenderness of cervix
8. Cul-de-sac tenderness
9. May or may not feel mass
10. Leucocyte count varies with attacks of pain

11. Sedimentation rate only moderately rapid

12. Positive Friedman test

Schumann, in his monograph on ectopic pregnancy, estimates that somewhat more than three-fourths of patients with ectopic pregnancy give the history of some irregular menstrual bleeding. In most of these the bleeding follows a period of amenorrhea which may vary from a few days' delay of menstruation to several weeks of absence. The bleeding is most often not profuse, is dark in color and is almost invariably associated with attacks of pelvic pain. Profuse external bleeding in a case of suspected ectopic pregnancy tends to indicate that the pain is more likely due to a threatened or incomplete abortion of an intra-uterine pregnancy. The close association of the bleeding with attacks of pelvic pain is, of course, attributable to the fact that the uterine decidua becomes detached as a result of death of the embryo incident to its separation from the tubal wall.

The pain in ectopic pregnancy is characteristically more sudden in onset and of greater severity than that encountered in any other strictly pelvic condition; so much so, that this point alone should arouse the suspicion of tubal pregnancy. Painful defecation and dyspareunia are quite commonly found in older cases in which a pelvic hematocele has formed.

The signs of shock and hemorrhage, particularly when superimposed on the clinical picture just described, leave little doubt of the correct conclusion. The leucocyte count characteristically varies directly with the occurrence of hemorrhage into the peritoneal cavity, being often quite high shortly after the onset of an attack, only to subside almost, if not quite, to normal between episodes of bleeding. The sedimentation rate, in our experience, has been relatively slow unless determined during or shortly after massive internal bleeding.

On examination one usually finds signs suggesting early pregnancy: a succulent vagina, a soft and bluish cervix, together with enlargement of the uterus often to the

size of a two months' normal pregnancy. Polak always stressed the extreme, even exquisite, tenderness of the cervix, particularly on motion toward the symphysis, as almost pathognomonic of ectopic pregnancy. Excruciating tenderness in one or the other lateral areas is the only consistent adnexal finding. Soon after rupture or tubal abortion has occurred, the consistency of the mass and the free intraperitoneal blood is such that extreme tenderness is, indeed, the only positive finding. In the older cases, however, in which some degree of organization has occurred, masses of considerable size can be easily detected in the cul-de-sac and adnexal areas.

The Friedman test, if positive, in a typical case, is undoubtedly of great aid in establishing the diagnosis. Dependent as it is, however, on the presence of functioning chorionic tissue, the test is unfortunately negative in many cases of ectopic pregnancy. In doubtful cases exploration of the cul-de-sac through the posterior vaginal vault, either by aspirating needle or incision, is of invaluable aid, particularly in differentiating between ectopic pregnancy and inflammatory disease.

#### TWISTED OVARIAN CYST

##### Chief Diagnostic Points

1. Previous knowledge or suspicion of cyst
2. No history or signs of infection
3. No history suggesting pregnancy
4. Shock often profound
5. Fever and leucocytosis are delayed
6. Sedimentation rate little affected
7. Red cell count not affected unless hemorrhage supervenes
8. Discovery of cyst on examination

In those cases in which a cyst has previously been known to exist the diagnosis of a twist of the pedicle is relatively simple. The same is true also in those cases in

which, on examination, a large cyst can be distinctly palpated. On the contrary, cysts of smaller size, particularly when tender as result of a twist, are easily mistaken for ectopic pregnancy; this is especially true when the twisted cyst complicates an early intra-uterine pregnancy. The pain of the twisted cyst is usually not so intense as in ectopic pregnancy; vaginal bleeding is rarely associated with it and the degree of shock is usually not so profound. The absence of a rapid drop in the red cell count in a shocked patient would tend to suggest a twisted cyst as opposed to ectopic pregnancy. On the other hand, the rapid development of anemia might well be due to hemorrhage into the twisted cyst. Since, in such cases, differentiation is well nigh impossible, it is indeed fortunate that immediate laparotomy is imperative in either event.

#### URETERAL STONE

##### Chief Diagnostic Points

1. Severe colic
2. Urinary reference of pain
3. Frequency and urgency
4. Red cells in urine
5. Positive x-ray and cystoscopic findings

Pain of intense lancinating severity should at once suggest the possibility of a stone in the ureter. The gynecologist who is aware of the ease of mistaking lesions of the urinary tract for those more strictly of pelvic origin will make more frequent use of consultation with the urologist in suspicious cases. Since the methods of diagnosis of stone are almost positively conclusive, it seems unnecessary in this presentation to discuss them at any length.

In closing this brief discussion the author reiterates the necessity of evaluating the clinical picture as a whole rather than depending on any one sign or symptom as pathognomonic.



# DIAGNOSIS OF DEHYDRATION IN SURGICAL CONDITIONS\*

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THERE are four main types of fluid in which the body is likely to become deficient. These are: (1) Water, (2) extracellular fluid (water + salt), (3) plasma (water + salt + protein), and (4) blood (water + salt + protein + cells).

Loss of plasma and loss of blood are not commonly referred to as "dehydration" and will not be included in the present discussion. Blood shortage is generally spoken of as "hemorrhage" or "anemia." Plasma shortage has no particular designation, except when it results in shock, in which case it may be referred to as "burn shock" or "wound shock." Occasionally, plasma loss is referred to as "dehydration." However, in the present discussion we shall deal only with conditions arising from shortage of water and shortage of salt. We shall deal, therefore, with two conditions, both of which are commonly referred to as "dehydration," but which, as will be pointed out, are quite dissimilar.

First we shall review a few fundamental facts concerning the distribution and metabolism of water and salt in the body. Then we shall consider the manifestations which arise when the body is deficient in these substances.

## DISTRIBUTION OF WATER AND SALT IN THE BODY

About 70 per cent of the body is water.<sup>1</sup> Since all body membranes are freely permeable to water, this substance distributes itself in accordance with the laws of osmotic equilibrium. For the purposes of this discussion there are three important fluid compartments in the body, each of which contains fluid of a characteristic type: Intracellular water accounts for about 50 per cent of the total body weight (or 70 per cent of the body water). Intra-

cellular fluid is relatively rich in potassium, but contains little or no sodium or chloride.<sup>1</sup> Extracellular fluid, which is relatively poor in potassium and rich in sodium and chloride, consists of two parts, namely, the blood plasma and the interstitial fluid. The blood plasma contains about 7 per cent of protein, while the interstitial fluid is practically protein free.

Thus, the distribution of water between intracellular and extracellular compartments depends, other things being equal, upon the amount of sodium in the body.<sup>1</sup> (The amount of chloride in the body is of only minor importance, as a chloride deficiency is readily compensated for osmotically by an increase in bicarbonate. Sodium, on the other hand, which constitutes about 90 per cent of the extracellular base, is not replaceable to any significant extent except by sodium itself.) Similarly, the distribution of extracellular fluid between plasma and interstitial compartments depends, other things being equal, upon the amount of protein in the plasma. The inorganic extracellular electrolytes, such as sodium, pass freely through the capillary walls and, therefore, can have little if any effect upon the distribution of water between the plasma and the interstitial compartments.

## DAILY REQUIREMENTS OF WATER AND SALT

The normal person can tolerate total abstinence from salt for days and perhaps weeks without ill effects. The excretion of sodium and chloride in the urine under such circumstances practically ceases and the losses from the body become negligible. A salt deficiency is not likely to develop unless there is a definite abnormal loss,

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such as occurs in vomiting, diarrhea, profuse sweating or Addison's disease.

Total abstinence from water, on the other hand, cannot be tolerated for more than a few days. The body possesses no mechanism for preventing the inexorable daily losses of water. A liter or more of water is frequently lost daily by evaporation from the skin and lungs, even in a dehydrated patient.

The contrast between salt and water requirements may be stated in a different way: Loss of water, both sensible and insensible, is taking place all the time so that there is a *daily* need for relatively large quantities of water even when there is no abnormal water loss. Need for salt, on the other hand, arises as a rule, only when there has been some definite *abnormal* loss. And once this salt loss has been made good, assuming that the abnormal loss has ceased, administration of additional salt is useless and may in some cases be actually harmful. Normally, the kidneys will excrete promptly an excess of either water or salt.

In the case of salt we may properly think of the daily intake as an independent variable and the output as a dependent variable. In the case of water the daily outgo is, up to a certain point, the independent variable while the intake is the dependent variable, insofar as the water intake is governed by the sensation of thirst. The mechanism of thirst practically guarantees a normal water intake in a normal individual. There is no similar mechanism to guarantee a normal salt intake, nor need there be under ordinary circumstances, for it is a *most unusual* diet that does not contain an excess of salt.

#### TWO TYPES OF DEHYDRATION

Dehydration is of two distinct types or some combination of the two, depending upon whether it is due to (1) inadequate water intake, (2) abnormal fluid loss, or (3) both of these factors working simultaneously.<sup>2</sup> At first glance it would appear entirely immaterial whether dehydration

results from one or the other of these factors; the net result might be presumed to be the same. Such, however, is not the case.

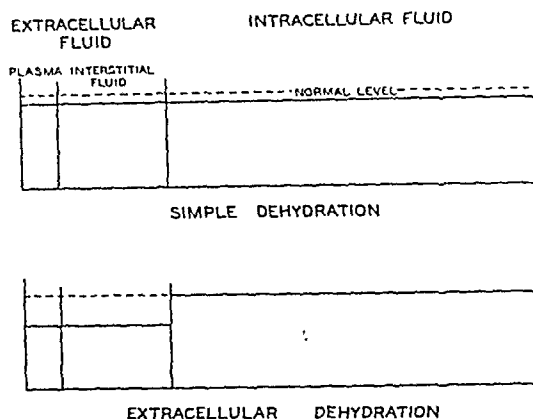


FIG. 1. Amount and distribution of body water in simple dehydration and in extracellular dehydration.

When dehydration results from inadequate water intake the shortage of water is not accompanied by an abnormal loss or salt. Therefore, the deficiency of water is felt in all parts of the body, within the cells as well as in the extracellular compartments. There occurs no maldistribution of water in this condition because there is no significant change in the amount or distribution of dissolved substances. The manifestations consist of *thirst*, oliguria, concentrated urine, and a rising blood non-protein nitrogen.

When dehydration results, on the other hand, from abnormal fluid loss, there occurs a simultaneous loss both of water and of extracellular electrolytes, chiefly sodium and chloride. The loss of sodium results in a corresponding loss of extracellular water, and there occurs a diminution in extracellular fluid volume (including plasma volume) even though the water intake is normal. As the condition advances, manifestations of circulatory failure develop. There occur weakness, apathy, anorexia, fainting, hypotension, shock, anuria and death. Before any of these symptoms are apparent, there occurs a progressive hemoconcentration. *Thirst is not present*. The urinary output may be normal until the stage of circulatory failure



is reached. Since this condition is characterized by a reduction in extracellular volume (including, of course, the plasma volume), we have referred to it as "extracellular dehydration" or "extracellular desiccation," in contrast to "simple dehydration." In Figure 1, the essential difference between the two types of dehydration is diagrammatically illustrated. In Table 1 are listed the outstanding manifestations of these two distinct entities.

#### DIAGNOSIS OF SIMPLE DEHYDRATION

When seen in pure form, simple dehydration presents no particular problem in diagnosis. The condition arises whenever an individual for any reason cannot obtain, cannot ingest or cannot absorb the water which he needs. The resulting manifestations are thirst, dry mouth, oliguria, concentrated urine and a rising blood nonprotein nitrogen. (Table 1.)

TABLE 1  
MANIFESTATIONS OF THE TWO TYPES OF DEHYDRATION  
WHEN SEEN IN PURE FORM

Simple (True) Dehydration	Extracellular Desiccation
Thirst	Weakness and apathy
Dry mouth	Anorexia or nausea
Oliguria	Low blood pressure or shock
Concentrated urine	Hemoconcentration
Rising nonprotein nitrogen	Often hypochloremia
	Sometimes anuria and rising nonprotein nitrogen if blood pressure sufficiently low

The symptom of thirst is a very sensitive indication of the need of the body as a whole for water. There is evidence that thirst is closely related to *cellular* dehydration.<sup>3</sup> Oliguria, but not anuria, is also a cardinal manifestation of simple dehydration (except in diabetes insipidus). The azotemia of dehydration is due chiefly to the associated oliguria.

The degree of dehydration may be difficult to judge in some instances. In general, the degree of dehydration seems to be in direct proportion to the intensity of thirst, and it is unfortunate that thirst does not lend itself to quantitative measurement. The degree of oliguria decidedly is not an

accurate index of the extent of dehydration.<sup>2</sup> A moderately, and also a severely, dehydrated person will generally excrete around 400 cc. of urine per day. The level of blood nonprotein nitrogen may be of some aid, provided too much emphasis is not placed upon this one finding. Other things being equal, the higher the level of the blood nonprotein nitrogen, the longer has been the duration and the greater is the extent of the dehydration.

Coller and Maddock found that subjects placed on a dry diet developed nitrogen retention and severe thirst in three or four days, by which time they had become dehydrated to the extent of 6 per cent of their body weight.<sup>4</sup>

At the present time there exists no perfect clinical method for estimating the degree of dehydration. Although the McClure-Aldrich test has been recommended by some, a recent study carried out by MacIntyre, Pedersen and Maddock found the test to be unreliable.<sup>5</sup>

From the practical standpoint, it is not necessary to make a quantitatively accurate diagnosis in cases of simple dehydration. In any case, one must administer water (or glucose solution) until the manifestations of dehydration have completely disappeared, that is, until thirst is relieved and diuresis is established (at least 1,000 cc. of urine daily), and until the blood nonprotein nitrogen has returned to normal.

#### DIAGNOSIS OF EXTRACELLULAR DEHYDRATION

The diagnosis of extracellular dehydration is not always a simple matter. It is easily overlooked, especially in the earlier stages when there are no striking signs or symptoms to announce its presence. The symptoms of weakness, apathy and anorexia which precede the onset of circulatory collapse, are likely to be attributed erroneously to other causes.

Extracellular dehydration must be thought of and watched for in any patient who is losing electrolytes abnormally,

whether from the skin (profuse sweating), from the gastrointestinal tract (vomiting, diarrhea, fistula), or through the kidneys (Addison's disease). Among surgical patients extracellular dehydration is most likely to arise among those who are losing fluid abnormally from the gastrointestinal tract. The sequence of events is likely to be somewhat as follows: A patient with profuse drainage from a biliary fistula or from an ileostomy is enjoying an apparently normal postoperative convalescence, is drinking plenty of water and is excreting a good volume of urine. About seven to fourteen days after the operation, he complains of weakness and loss of appetite and perhaps nausea and vomiting. A day or two later it is discovered that the patient has not voided for twenty-four hours. Catheterization yields only 20 cc. of urine. The pulse is found to be weak and the blood pressure is discovered to be 60 mm. of mercury systolic. The plasma chloride concentration is 460 per cent (normal 560) and the blood nonprotein nitrogen is 60 mg. per cent. The intravenous administration of three or four liters of saline or Ringer's solution results in dramatic recovery, if carried out promptly. The daily administration, orally or parenterally, of an amount of sodium chloride equivalent to the daily losses (usually 5 to 20 Gm.) will prevent recurrence. In one such case personally observed by the author it was necessary to administer over 20 Gm. of sodium chloride daily in order to replace the losses (ileostomy) and to prevent the recurrence of shock.

When extracellular dehydration progresses to the point of shock, we have occasionally referred to the condition as "electrolyte shock." In the past the condition frequently has been referred to as "hypochloremic shock," but this is a misleading term for "hypochloremia" bears no essential relationship to the condition in question. If, for instance, extracellular dehydration results from diarrhea, the plasma chloride concentration may be normal, or even increased, and yet the

patient may be in dire need of sodium chloride solution. Of course, the prime need is for sodium, the chloride playing an incidental rôle. The shock which occurs is indistinguishable clinically from other types of hemogenic shock. It results from a diminished blood volume, as the associated hemoconcentration indicates.

TABLE II  
CONDITIONS LIKELY TO GIVE RISE TO THE DIFFERENT  
TYPES OF DEHYDRATION

True dehydration (Loss of water)	{ Simple water deprivation Marked dysphagia Marked anorexia
Extracellular desiccation (Loss of sodium chloride and water)	{ Diarrhea (e.g., cholera) External fistulas Addison's disease Profuse sweating
Mixed type	{ Intestinal obstruction Vomiting from any cause Wangensteen suction

To make the diagnosis of extracellular dehydration before circulatory collapse occurs, one must depend upon clinical and laboratory observations, including determinations of the blood pressure, hematocrit, plasma protein concentration, plasma chloride concentration and carbon dioxide combining power. If the blood pressure is low, circulatory collapse should be considered imminent; but before the blood pressure falls there will be found a progressive hemoconcentration. Also there will generally be found some alteration in the plasma chloride concentration and often in the plasma carbon dioxide combining power, depending upon the composition of the fluid which has been lost from the body.

One must, of course, be cautious in the evaluation of hemoconcentration. One patient observed by the author had had a recent ileostomy performed for chronic ulcerative colitis and was losing between four and five liters of liquid feces daily. This patient went into shock and was found to have a hematocrit of 53.3 per cent and a plasma protein concentration of 8.0 per cent. (Table III.) The administration of fluid containing 31 Gm. of sodium chloride resulted in dramatic improvement and a reduction in the hematocrit and plasma protein concentration to 41.4 per cent and

6.5 per cent, respectively. During the following day, however, only 8 Gm. of sodium chloride were administered and the patient developed mild shock. The hematocrit and plasma protein concentration were found to have risen again. (Table III.) The administration of fluid containing 38.5 Gm. of sodium chloride completely relieved the symptoms once more and resulted in a return of the hematocrit and plasma protein concentration to what were probably their true levels (35 per cent and 5.4 per cent, respectively). It is thus important to bear in mind that if a patient has anemia and hypoproteinemia before hemoconcentration occurs, the hematocrit and plasma protein concentration may not rise above the normal level, though the patient may be in desperate need of saline therapy. In such cases the diagnosis is more difficult and it is probably wise to play safe and supplement the saline therapy with transfusions of blood or plasma and it is certainly wise to watch closely for the development of edema.

hydration. When the sodium losses are great, the corresponding losses of extracellular water with resulting hemoconcentration may mask the shortage of chloride. Our chemical determinations do not tell us how much chloride has been lost from the body but merely inform us of the chloride concentration in the specimen examined. Also, in evaluating the results of saline therapy one must not expect the plasma chloride concentration to return promptly to normal except in those cases in which the disease is of short duration. Several days may be required to accomplish this. (Table III.)

#### DIAGNOSIS OF MIXED TYPE OF DEHYDRATION

It is very common for the two types of dehydration to co-exist in the same patient. Vomiting commonly gives rise to the mixed type because a patient who is vomiting not only is losing sodium and chloride but also is generally unable to drink a normal amount of water. In such cases each of the

TABLE III\*

Days	Intake		Output (Urine), Cc.	Blood			Remarks
	Water, Cc.	Sodium Chloride, Gm.		Hemato- crit, Per Cent	Plasma Protein, Gm. Per Cent	Plasma Chloride Mg. Per Cent (as Sodium Chloride)	
0	....	....	....	53.3	8.0	460	In shock
1	4925	31.0	1050	41.4	6.5	507	Improved
2	2825	8.0	400+	48.7	6.8	465	Mild shock
3	6000	38.5	1030+	35.1	5.4	508	Marked improvement
4	4900	26.0	670	34.9	5.3	512	Feels well; plasma transfusion 500 cc.
5	3800	23.4	960	34.3	5.3	498	Feels well; plasma transfusion 400 cc.
6	3600	19.5	1420	36.3	5.6	508	Feels well
7	5495	23.8	980	38.8	5.5	...	Feels well; blood transfusion 500 cc.
8	4250	21.0	780+	33.6	4.7	578	Feels well

\* Patient L. S. Ileostomy for chronic ulcerative colitis. Extracellular dehydration and shock from loss of large amounts of fluid containing extracellular electrolytes.

Determinations of plasma chloride concentration are of definite aid in diagnosis, but it should be remembered that normal values do not rule out extracellular de-

two types of dehydration must be diagnosed on its own merits. This should cause no difficulty because the two conditions have practically nothing in common.

A patient who has been vomiting or who has both diarrhea and vomiting or a patient with intestinal obstruction should automatically be suspected of having the mixed type of dehydration. The simultaneous presence of thirst, oliguria, weakness, apathy and anorexia make such a diagnosis highly probable. The diagnosis will be made more certain by the finding of hypotension or shock, an elevated hematocrit and plasma protein concentration, a rising blood nonprotein nitrogen, and a lowered plasma chloride concentration.

If mixed dehydration is not recognized and is treated either by physiological saline alone or by glucose solution alone, the dehydration may then become converted into one or the other of the pure types. The author has seen this actually happen.

The common occurrence of the mixed type of dehydration probably explains the failure of most observers in the past to distinguish clearly between the two component types.

#### SUMMARY

1. Some fundamental facts concerning the distribution and turnover of water and salt in the body are reviewed.
2. Simple dehydration and extracellular dehydration are discussed with respect to mechanism of production, symptomatology and diagnosis.

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# VITAMIN THERAPY IN THE SURGICAL PATIENT\*

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RECENT experimental and clinical literature has continued to emphasize the importance of adequate vitamin maintenance in pathological conditions of an obviously surgical nature. This emphasis has largely risen from repeated demonstrations that deficiency in certain if not all of the accessory food factors produces local and constitutional changes of such nature that surgical treatment attempted in the presence of deficiency may become more hazardous and recovery imperilled. The purpose of this communication is to reiterate several aspects of vitamin therapy in general and correlate their importance to surgical treatment in particular.

To facilitate the discussion, all vitamin complexes may be divided arbitrarily into two groups: (1) Vitamin factors essential in adequate amounts for maintenance of normal health and nutrition but deficiency of which is not of primary surgical importance; (2) vitamin factors essential in adequate amounts for maintenance of normal health and nutrition but deficiency of which directly increases surgical risk. However vitamin factors are arbitrarily divided or classified, certain well established clinical concepts are common to all as a general nutritional group. A general consideration of these concepts is essential to a more specific discussion of those having particular surgical consequence.

Definite amounts of all vitamins are required for complete maintenance of body nutrition and function. With an adequate diet, under normal conditions of digestion, more than is requisite is available. When, however, the diet becomes inadequate in vitamin yielding substances, or the physio-

logical processes making them available become impaired by disease, a deficiency in the body vitamin content is the result. Such deficiency may exist in one or all of the vitamin substances and, when of sufficient severity and duration, is reflected by impairment of various body tissues and functions. Ultimately, if unrelieved, such deficiency becomes apparent by ordinary clinical methods. But subclinical deficiencies are of far more frequent occurrence. It is not to be presumed, therefore, that because the degree of vitamin deficiency is not outwardly apparent, no deficiency exists. For it has been substantially proved that deficiency of such a degree to cause marked alteration in tissue functions and structure can be extant without grossly detectable change. It should not be inferred from the foregoing that every individual must have one or more vitamin deficiency. It is implied, however, that every individual case may have a potential deficiency. Deficiency states do not develop in normal individuals taking normal well balanced diets. They are, however, particularly prone to develop in the following commonly encountered groups in surgical practice:

1. Individuals on restricted dietary régimes indicated in the treatment of incidental disease, e.g., diabetes, peptic ulcer, obesity.

2. Individuals taking pharmacological agents into the gastrointestinal tract which inhibit absorption or destroy the vitamin substances ingested. Examples of these instances are frequent. It is generally conceded that excessive ingestion of mineral oil prevents absorption of the fat soluble vitamins A, D and K.<sup>1,2</sup> Alcohol in excess

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notably results in decreased ingestion of all food and of B complex in particular.<sup>3,4,5</sup>

3. Individuals in which a particular disease, usually of the gastrointestinal tract or its attendant secretory organs, precludes the absorption of the vitamin substances ingested or after absorption interferes with proper utilization. An example of this condition is vitamin K deficiency in gallbladder disfunction causing lack of bile for the emulsification and absorption of fatty substances with consequent reduction in the vitamin K level of blood and tissues.<sup>6,7,8</sup>

It should be borne in mind constantly that vitamin substances are, individually and as a group, specific nutritional identities, each of which produces changes more or less specific in body tissue and functions, and that the pathological changes induced by the deficiency respond specifically to adequate amounts of the proper vitamin substance. This specificity together with pertinent therapeutic addenda is recalled in Table I:

two groups: The first of these includes those vitamins of minor or indirect surgical importance, the second includes those of major surgical interest.

*Group I. Vitamin Factors of Minor Importance in Surgical Treatment.* The constituents of this group include vitamins A, D and E which for convenience and clarity are considered individually.

#### VITAMIN A

Vitamin A is a fat soluble, water insoluble, crystalline substance closely allied though not identical with the compound  $\beta$  carotene. It is of wide distribution in plant and animal bodies and occurs in large amounts in pigment and vegetable substances. The vitamin itself is a primary alcohol of which  $\beta$  carotene is the predominant precursor, which is converted in the liver to the vitamin proper. Two important physiological functions depend upon the presence of sufficient quantities of the vitamin.<sup>8,9,10</sup>

1. Visual adaptation to darkness which

TABLE I\*

VITAMIN	CHEMICAL SUBSTANCE	PHYSIOLOGICAL FUNCTION	DEFICIENCY SYNDROME	APPROXIMATE ADULT DAILY REQUIREMENT
A	BETA-CAROTENE	VISUAL ADAPTATION TO DARK INTEGRITY OF BODY EPITHELIUM	NIGHT BLINDNESS KERATITIS & EPITHELIAL ULCERS	8000 UNITS
B	THIAMIN	ESSENTIAL ELEMENTS IN CELLULAR OXIDATION	NERVOUS & CARDIO-VASCULAR DISORDERS (BERI-BERI)	30 UNITS
B	RIBOFLAVIN	SAME	LESIONS OF BUCCAL MUCOSA	3 MGMS
B	NICOTINIC ACID	SAME	CEREBRAL, GASTRO-INTESTINAL & SKIN DISORDERS (PELLAGRA)	150 MGMS
B	OTHER FACTORS			
C	ASCORBIC (VITAMIN C) ACID	COLLAGEN FORMATION & CONNECTIVE TISSUE CELL PROLIFERATION	ABNORMALITIES IN CONNECTIVE TISSUE STRUCTURE OF BODY TISSUES & HEALING PROCESS (SCURVY)	120 UNITS
D	CALCIFEROL (VIT D2) ACTIVATED DEHYDRO- CHOLESTEROL (VIT D3)	Ca ABSORPTION FROM GASTRO- INTESTINAL TRACT & RENAL Ca & P EXCRETION	BONY ABNORMALITIES RICKETS DELAYED BONE HEALING	200 UNITS
E	ALPHA-TOCOPHEROL	GESTATION & STRIATE MUSCLE IN EXPERIMENTAL ANIMALS	NOT DEFINITE IN HUMANS	NOT DETERMINED
K	2-METHYL-3-PHYTYL-1, 4 NAPHTHOQUINONE	PROTHROMBIN FORMATION IN BLOOD CLOTTING PROCESS	DELAYED CLOTTING TIME HEMORRHAGE	1 MGM

\* Compiled by authors from various sources.

It was previously stated that to facilitate discussion of these vitamin factors of particular consequence from the surgical standpoint, a division of the entire group of vitamins would arbitrarily be made into

is dependent on speed of breakdown and resynthesis of the visual purple (rhodopsin) substance of the retina. Rhodopsin is apparently a compound composed of a protein and a prosthetic group presumed to

be vitamin A. In deficiency states the ability of dark accommodation is rapidly and severely affected giving rise to the condition of night blindness or nyctalopia. This condition can usually be rapidly corrected by the administration of adequate vitamin substance.

2. The integrity of epithelial structure and function is maintained only in the presence of normal body vitamin A content. The physiological processes which condition the presence of the vitamin has not as yet been elucidated. But lack of the vitamin has been shown to produce epithelial atrophy with subsequent proliferation of the basal cells and replacement with a modified epithelium. This deficiency effect is particularly evident in the epithelium of the cornea, skin, respiratory tract, urinary passages and mucosa of the gastrointestinal tract. Of consequence corneal and skin lesions, increased susceptibility to respiratory tract inflammation, urinary calculi and gastrointestinal pathological conditions arise from the more advanced deficiency states.

The average daily minimum requirement is in the neighborhood of 2,000 international units. The unit standard is reckoned on a basis of the quantity of the vitamin required to promote normal growth in rats of a standard age and weight fed on an A deficient diet over a specific time interval. The international unit of which the U.S.P. unit is the equivalent represents the physiological activity of .006 mg. of purified  $\beta$  carotene. During periods of growth and pregnancy or in deficiency conditions the dosage of vitamin A should be proportionately increased.

From the foregoing consideration of vitamin A substance it can be concluded that the relation of this vitamin and the deficiency states arising from its lack have only a rather remote and indirect application to surgical therapy. Deficiency in vitamin A may serve as an index to a coincident deficiency in the other fat soluble vitamins, D, K and E, since they are also fat soluble and are influenced by the

same common conditions of dietary content and absorption. It is moreover conceivable that in severe degrees of vitamin A depletion the epithelial changes produced may interfere considerably with tissue repair after surgery, either because of atrophic changes which occur or susceptibility to secondary infection.

#### VITAMIN D

Numerous sterol substances of plant and animal origin when irradiated with ultra violet light are changed in internal structure so that they possess vitamin D activity.<sup>11,12</sup> Of these substances the most important are: (1) Calciferol or vitamin D<sub>2</sub> produced by the irradiation of ergosterol; (2) dihydrotachysterol formed by the reduction of tachysterol which is another of the products of the progressive radiation of ergosterol; and (3) activated dihydrocholesterol or vitamin D<sub>3</sub> synthesized by the irradiation of 7-dihydrocholesterol.

Two of the three foregoing substances, namely, calciferol and activated dihydrocholesterol, though not identical in chemical structure and physiological activity, are sufficiently similar to be classed under the general term of vitamin D. The third substance, dihydrotachysterol, differs considerably in its physiological action and will be separately considered.

Vitamin D is one of the fat soluble vitamin group. It can be made available to the body in adequate quantities only when it is present in sufficient amounts in the diet and under conditions of adequate fat absorption from the digestive tract. When the preparation for or absorption of fatty substances of the diet are impaired from whatever cause, D deficiency is apt to result. The vitamin D factor is closely related to the body phosphorus and calcium. Together with the parathyroid glands it regulates to a large measure the calcium and phosphorus blood levels. The principal action of vitamin D in this relationship is to facilitate the absorption of calcium from the gastrointestinal tract. Beside being essential for calcium absorp-

tion, it apparently is capable of producing excretion of phosphorus by the kidney, which, if continued, results in withdrawal of calcium from the bones. In this latter action, vitamin D resembles the active secretion of the parathyroid which mobilizes calcium from storage in the bones but does not influence its absorption from the digestive tract. The typical rachitic lesions of vitamin D deficiency are produced by the inability of the body to absorb sufficient calcium from the gastrointestinal tract. In this state the blood calcium level would markedly fall if calcium were not withdrawn from the bone calcium deposits to maintain it. The withdrawal of calcium from the bone to maintain the calcium blood level results in rickets or osteomalacia with consequent deformity. In contrast it is possible to produce the reverse of deficiency conditions by the administration of enormous amounts of active vitamin D substance. Under these circumstances there is considerable elevation of the blood calcium and phosphorus level at the expense of bone deposits, with the formation of calcareous concretions in the gastrointestinal tract, vascular system, renal parenchyma and liver.

The action of dihydrotachysterol, although a related member of the vitamin D group, differs quantitatively in action from the two previously mentioned substances. It facilitates calcium and phosphorus absorption from the gastrointestinal tract but its greatest action is upon calcium excretion. Dihydrotachysterol produces a marked increase in phosphate excretion by the kidney which causes a concomitant renal excretion of calcium. To maintain the calcium blood level, skeletal calcium is liberated into the blood. This mobilization of bone calcium is in many respects similar to parathormone, the secretion of the parathyroid gland which also mobilizes calcium and maintains the blood level by a similar mechanism.<sup>13</sup>

Vitamin D deficiency states are reflected in low blood calcium levels and in abnormalities of bones, resulting in the typical

rachitic syndrome. Such deficiency is particularly prone to occur in infancy and early childhood, critical periods of bony growth, in pregnancy when the vitamin requirements are considerably increased, and in the aged in whom the dietary intake is apt to be abnormally low.<sup>14,15</sup>

Considerable variation in the daily requirements exist therefore depending on the age of the patient. Infants on artificial diets should have 500 to 1,000 units daily. Breast fed infants on whole cows milk régime 250 to 500 units and older children ought to receive a similar amount. In adults, particularly those of sedentary occupation, supplemental vitamin D may be of benefit in amounts of 150 to 200 units. During pregnancy and lactation, quantities are essential in the neighbourhood of 1,000 units. In aged individuals, suffering from bone injuries, the administration of 100 to 200 units daily depending on the diet, may be considered advisable. When severe deficiency exists, the dosage must be greatly increased, and in these instances daily amounts of from 20,000 to 30,000 units may be employed. In all instances in which vitamin D is given, an adequate calcium intake should be assured.

The international unit on which vitamin D administration is based has been agreed upon as the physiological activity of .0025 mg. of crystalline calciferol.

Indications for the use of vitamin D may be included in the following: (1) All cases of suspected deficiency. In these instances the dosage is required in therapeutic amounts; (2) prophylactically in infants, children, pregnant or lactating women and in individuals of sedentary indoor habits. (3) cases of bone injury, particularly in the aged; (4) Gastrointestinal diseases in which fat absorption is apt to be inadequate and, therefore, reduce the availability of vitamin D.

#### VITAMIN E

In the present state of investigation, only a passing notice need be taken of vitamin E. This arises from the fact that its indis-



pensability in the human has not been proved and information regarding it rests almost entirely upon a basis of animal experimentation.

Vitamin E is a fat soluble substance existing in several tocopherol forms. Of these forms, alpha tocopherol possesses the greatest activity and is readily inactivated by oxidation.<sup>16,17</sup>

Symptoms of deficiency are notably shown by the effect on gestation and the effect on striate muscle in rats. Clinical application of vitamin E in the human is, as previously suggested, extremely limited. It has been advanced as a form of therapy in habitual abortion, certain degenerative diseases of the nervous system and in muscular dystrophies. Its efficacy in these conditions is doubtful and lacks confirmation.

#### VITAMIN P

Vitamin P (lemon eroidictin) is a recently isolated substance. There are disputed claims that it is of value in the treatment of purpura. To date the value of its use in man has not been established.<sup>18</sup>

*Group II. Vitamin Substances of Major Surgical Importance.*

#### VITAMIN K

The discovery and clinical application of the vitamin K factor represents one of the major recent advancements in medical research.<sup>19,20</sup> Its importance in surgical treatment can hardly be overemphasized, since it has greatly lowered the operative risk and mortality in one large group of diseases for which surgery in some form is the accepted essential treatment. The excellent results obtained in vitamin K therapy are based upon an increasingly intimate knowledge of its chemistry and physiological activity and a recognition of the pathological conditions in which its use is specifically indicated.

Investigations of its chemical nature have demonstrated that it is a fat soluble compound containing a quinone structure

that is present in a wide variety of vegetable and animal substances, notably in certain plants and in animal liver.<sup>21</sup> Further experimentation has shown that a large number of substances possess various degrees of vitamin K activity, but that vitamin K proper was not a single chemical entity but occurs in the natural state in the form of at least two separate compounds of related chemical structure. The substance selected as representative is 2 methyl-3 phytyl-1, 4 naphtho quinone or vitamin K.

Under normal physiological circumstances, articles of diet containing vitamin K are taken into the gastrointestinal tract where they are subjected to the action of the various digestive processes and the fat elements containing the K fraction liberated. This K containing fat fraction is mixed with and emulsified by bile and absorbed by the intestinal mucosa into the blood by which it is carried to the liver for immediate use and storage. The function of the vitamin K fraction is to provide an element in the formation by the liver of an essential blood clotting factor, namely, prothrombin. Prothrombin is then liberated into the blood in adequate quantities for normal clotting. The relationship of prothrombin to the other elements in blood coagulation process will be recalled by the following brief schema:

Thromboplastin + prothrombin  
+ calcium → thrombin

Thrombin + Fibrinogen → fibrin (clot).

Lack of any one of these essential elements inhibits the clotting process in direct proportion to the deficiency present. When all are present in sufficient quantity coagulation occurs normally. Deficiency in prothrombin is at once reflected by a clotting time prolonged in proportion to the extent of the deficiency present. Since the clotting process depends upon the presence of adequate quantities of prothrombin, and since prothrombin can be formed in adequate amounts only when there is absorption and utilization by the liver of requisite

amounts of vitamin K factor, it is obvious that the normal clotting process is ultimately dependent upon adequate amounts of vitamin K. From the foregoing it will be readily perceived that vitamin K and prothrombin deficiency can occur in any one of the following conditions: (1) Insufficient vitamin K in the diet; (2) Impaired absorption resulting from: (a) insufficient bile for conversion into an absorbable state; (b) abnormalities of the absorptive intestinal surface resulting from disease; (3) impaired liver function, resulting in the inability to form prothrombin.

Hence it would be expected that in inadequate diets, diseases of the biliary system, particularly those in which the flow of bile to the intestine is reduced or abolished, diseases of the gastrointestinal tract which interfere with the absorption of digested nutritional elements, and pathological conditions of the liver of such a nature that its function is impaired, would result in abnormal delay of the blood clotting process. This is actually the case.

Considered on the physiological basis outlined above, there are several groups of conditions which are intimately related to vitamin K and prothrombin deficiency:

1. The first group of patients with prothrombin deficiency to be considered are newborn infants.<sup>22,29</sup> This deficiency of prothrombin is apparently physiological and occurs in all infants, it being about 60 to 70 per cent of the normal adult value. There may be a marked fall twenty-four hours after birth which is usually of short duration. A spontaneous rise usually begins one or two days later, possibly due to the fact the infant begins to take food and bacterial flora are established which synthesize vitamin K. If spontaneous recovery is delayed, hemorrhagic disease develops. In such instances the prothrombin level may be as low as 5 per cent of normal, which may be corrected rapidly by the administration of vitamin K.

2. The second group of prothrombin deficiencies are those due to an inadequate

intake of vitamin K in the diet. Experimentally, these have not been produced in mammals by means of a vitamin K free diet alone, and in man such a vitamin K deficiency is exceedingly rare. Several cases are reported but other deficiencies were present. The explanation of the rarity of this condition is thought to indicate that bacterial activity in the gut must produce enough vitamin K to meet minimal requirements.

3. The third group of prothrombin deficiencies are those in which for some reason there has been a failure of absorption of K from the gastrointestinal tract. This group is by far the most important one to consider. It is now known that the absorption of a fat soluble vitamin requires the presence of bile of normal composition in the gut. The feeding of fat soluble vitamin K alone in the absence of bile has little or no effect on the control of prothrombin deficiencies, whereas, if bile or bile salts are given with the same amount of vitamin K, there is an immediate increase of prothrombin in the circulating blood.<sup>23,24,25</sup> It is further known that the feeding of bile alone will correct prothrombin deficiencies by facilitating the absorption of vitamin K which is normally present in the gut. In this group then, in which there is a failure of vitamin K absorption, we must first consider:

1. Those cases due to simple exclusion of bile from the gut as produced by a biliary fistula.<sup>26</sup>
2. Those due to obstruction resulting from stones, strictures, tumors, or inflammatory processes.
  - (a) If complete obstruction exists, vitamin K is not absorbed.
  - (b) If there is a partial obstruction there may be a decrease in bile salt formation so that the character of the bile may change to such an extent that it will not facilitate the absorption of vitamin K.<sup>23,24</sup>
  - (c) Hepatic damage; this is a variable factor depending on the nature

and duration of the obstruction and the presence of infection. If severe, the storage and utilization of vitamin  $\kappa$  may be interfered with.<sup>24</sup>

3. In certain lesions<sup>27</sup> there is deficiency of prothrombin due to inadequate absorption resulting from unusual losses:

- (a) Diarrhea, chronic ulcerative colitis, sprue.
- (b) Vomiting in intestinal obstruction, prolonged gastroduodenal suction.
- (c) Inadequate absorptive surface, gastrocolic fistula, enterostomies, short-circuiting operations.

4. In the fourth group the prothrombin deficiency is due to primary hepatic damage.<sup>28</sup> Here there is no vitamin  $\kappa$  deficiency, but rather there is an inability on the part of the liver to form prothrombin. The ability on the part of the liver to form prothrombin is probably one of the last functions lost. In this group there is a failure to respond to vitamin  $\kappa$  (obstructive biliary cirrhosis, advanced acute or chronic parenchymatous disease of the liver).

It has already been pointed out that a number of similar substances possessing the quinone structure show vitamin  $\kappa$  activity. No standard universal unit expressing  $\kappa$  potency as yet exists but the one in widest use at the present time defines a unit of  $\kappa$  in terms of the smallest amount of  $\kappa$  substance per Gram weight of experimental chick per day that will produce normal coagulation time in chicks deprived of  $\kappa$  after three days of oral administration.

The fat soluble substances containing  $\kappa$  factor require bile or bile salts for their absorption from the gastrointestinal tract. Consequently, when these substances are used, bile essential for their utilization must be present either naturally, or therapeutically supplied. Water soluble compounds possessing the  $\kappa$  principle may be

utilized in the absence of bile and given parenterally.

A review of the conditions of prothrombin deficiencies related to  $\kappa$  deficiency is presented below together with specific points on therapy.

#### TREATMENT

Clinically vitamin  $\kappa$  therapy is of value:

(1) In the newborn; if vitamin  $\kappa$  is administered to the mother intravenously before or during labor, the baby is born with a high level of prothrombin. If surgery is necessary in a newborn infant, vitamin  $\kappa$  should certainly be administered.<sup>22, 29</sup>

(2) In preparation of the jaundiced patient for surgery vitamin  $\kappa$  is of great value. If 2 methyl-1, 4 naphthoquinone (which is fat soluble) is given by mouth together with dried whole bile for three to five days, it will usually bring prothrombin time to normal. Another preparation, the water soluble  $\kappa_5$ —(4 amino 2 methyl-1, 4-naphthol hydrochloric acid) may be given by vein.<sup>30</sup> If the response is poor, it is probably the result of extensive liver damage. The treatment should also be continued for several days postoperatively.

(3) In certain intestinal lesions such as intestinal obstruction associated with long continued vomiting, in ulcerative colitis, or polyposis associated with diarrhea; in the presence of a gastrocolic fistula, enterostomy or prolonged gastroduodenal suction, there may be a lengthened prothrombin time resulting from inadequate absorption of vitamin  $\kappa$  from the gut. Here parenteral administration of vitamin  $\kappa$  is indicated.

Vitamin  $\kappa$  has not proved useful in hemophilia, thrombocytopenic purpura, aplastic anemia, acute yellow atrophy or multiple myeloma. In cirrhosis of the liver and in severe hepatitis the response is often poor.

#### VITAMIN B

It has been demonstrated that vitamin B is not a single chemical and biological identity but is separable in a number of

individual components, each of which differs in chemical structure and physiological action. Although these substances are grouped together under the general term vitamin B complex, for the sake of convenience and as a concession to the older literature, they must be separately considered in any discussion concerning therapeutic values. Not all the individual components comprising the B complex will be enumerated here, but only those of immediate clinical interest. The subsequent discussion will, therefore, be limited to B components, thiamin, riboflavin and nicotinic acid.

#### THIAMIN

Analysis and synthesis of thiamin have proved it to be an organic compound formed by the union of a pyrimidine and thiazole nucleus.<sup>30</sup> It is a white water soluble crystalline substance readily absorbed from the gastrointestinal tract and rapidly taken up by the tissues. It has been estimated that approximately 10 per cent of the daily intake is metabolized and excreted by the urine. In instances of excessive intake the excretion is correspondingly greater and in the condition of elevated metabolism thiamin is more rapidly destroyed by the tissues and larger amounts are essential for maintenance of normal function.<sup>5</sup> This is particularly evident in hyperthyroidism.

Considerable evidence has accumulated indicating the fact that thiamin is of fundamental importance in the various stages of carbohydrate metabolism. Since practically all tissues of the body utilize carbohydrate in the discharge of their functions, thiamin deficiency is apt to result in marked disturbances throughout the body. Nervous tissue is particularly susceptible to derangement since carbohydrate is practically the sole substance metabolized.

Thiamin deficiency results in a symptom complex (beriberi) chiefly referable to the nervous and cardiovascular systems, with cardiac enlargement and irregular-

ity together with sensory and motor derangements involving the peripheral nerves.<sup>5,32</sup> In practically all instances these manifestations can be rapidly alleviated by providing the daily requirements.

An international unit of thiamin potency has been established as the physiological effect of 0.003 mg. of crystalline thiamin. At the present time, the daily requirement of the adult is presumed to be in the neighborhood of 30 international units.

Therapeutic indications for the use of thiamin with particular reference to surgery include:<sup>5,32</sup>

1. Preoperative preparation of alcoholic individuals. Chronically alcoholic cases are predisposed to serious diseases associated with vitamin B deficiency, particularly thiamin deficiency. The preoperative administration of adequate quantities of thiamin should be reckoned to correct any possible deficiency before surgery is undertaken.

2. Postoperative cases in which anorexia materially interferes with normal recovery. In these instances in which there is persistent lack of appetite, particularly if there is the possibility of a B deficiency, excellent improvement in appetite is frequently obtained by the daily administration of relatively large amounts of thiamin.

3. In instances in which surgery of the gastrointestinal tract is contemplated. The rationale of thiamin administration in these instances arises from an observation that thiamin deficiency produces various degrees of atony of the intestinal musculature with consequent impairment of function. Adequate thiamin administration is, therefore, indicated to preserve intestinal tone and function postoperatively.

4. In thyrotoxicosis when incident to the high basal metabolic rate there is increased destruction of thiamin. Due to the rapid rate of destruction, thiamin deficiency may develop even when intake and absorption are adequate. For the normal state it is, therefore, advisable to provide for this contingency preoperatively by giving increased amounts preoperatively.

## RIBOFLAVIN

The limited application of the riboflavin component of vitamin B complex in relation to surgical therapy warrants only the briefest discussion. Riboflavin is a yellow crystalline water soluble substance formed from the organic union of the chromophoric nucleus flavin in a molecule with the sugar  $\alpha$ -ribose. Its precise physiological function is obscure although it is presumed to be a component of all yellow oxidation enzymes and, therefore, an essential in cellular respiration. Deficiency of riboflavin produces a specific type of cheilosis and ocular manifestations including impaired vision, increased pigmentation of the iris and keratitis.<sup>33,34</sup>

Daily requirements are adequately provided for in an ordinary balance diet or by the administration of 2 or 3 mg. In instances of deficiency daily dosage up to 50 mg. for five days is advocated.

Specific indications for its use in relation to surgery are lacking.

## NICOTINIC ACID

Nicotinic acid is a white water soluble crystalline powder of basic pyrimidine structure. It is chemically allied to nicotine but has no pharmacological similarity to the latter substance. It is almost quantitatively absorbed from the gastrointestinal tract and other sites of administration. In human beings, in therapeutic doses, nicotinic acid rather promptly results in a vasodilatation.<sup>35</sup> There may be a marked blushing with mild burning or itching sensations. In order to obviate this unpleasant sensation the nicotinic acid amide is now more widely used therapeutically. In greatly increased quantities it is capable of producing toxic symptoms, at least in experimental animals.

Like the two former B complex substances it is apparently an essential constituent in the enzymatic control of cellular oxidation. Deficiency results in the pellagra syndrome with symptoms reflected in the skin by cutaneous eruptions, pigmentation and ulceration; in the gastrointestinal tract

by ulceration of the buccal mucosa, nausea, vomiting and diarrhea; and in the nervous system by vertigo, insomnia and peripheral nerve disorders.<sup>35</sup>

Specific therapeutic indications for the administration of nicotinic acid which are definitely related to surgery are difficult to enumerate. The chief indication for its use is in surgical cases in which the deficiency is diagnosed in preparation for surgery. It has been suggested as routine preoperative therapy in conjunction with thiamin and if this suggestion is accepted indications for its use are the same. This may also be said of riboflavin.

Nicotinic acid is employed therapeutically as nicotinic acid, as the amide or as the sodium salt. Variations exist in individual daily requirements being variously given as from 100 to 1,000 mg. When no deficiency is clinically apparent, a dosage of 50 to 100 mg. three times daily should be adequate preoperative dosage. In actual deficiency states this dosage can be increased four or five times without harm. Nicotinic acid or its derivatives may be given subcutaneously or intravenously when oral administration is not feasible. Occasional reactions are encountered in increased dosage consisting of blushing, pruritis and mild fever, rarely of abdominal pain, nausea and vomiting. These latter effects are transient and subside in a short time.

## VITAMIN C

Although the clinical symptoms associated with advanced vitamin C deficiency have been a familiar clinical syndrome for many years, its specific relation to the process of body repair of injured tissue has only recently been appreciated. Before considering this important function, a brief review of the general aspects of the vitamin C factor is appropriate.

Vitamin C is a crystalline, water soluble, optically active substance of acid form, to which the name of ascorbic acid and cevitamic acid has been given. It is isolated in greatest quantities from fruits of the citrus group and has been synthesized.

It is a strong reducing agent and is readily destroyed by oxidizing substances. Under usual circumstances there is almost complete absorption of vitamin c from the gastrointestinal tract, after which increased amounts may be directly measured in the blood. Quantitative determination of the blood level of vitamin c measured as ascorbic acid is the best single indication of its presence in adequate quantity. In the human being between 0.5 and 1.0 mg. represents the normal state while values below and above these values approach deficiency or saturation. Levels below 0.15 are invariably associated with outwardly manifest clinical signs of deficiency. It has been conclusively shown that when the blood and tissues become saturated with ascorbic acid that the excess is largely excreted through the kidney by a threshold mechanism which is in the neighborhood of 1.5 mg. per cent. Administration of the substance after a period of deprivation results in its rapid removal from the blood by the tissues. This tends to keep the blood level low. Because ascorbic acid is destroyed in the body by oxidation, constant replenishments are essential. Daily requirements in the human are in the neighborhood of from 20 to 50 mg. in children and 50 to 100 mg. in adults. In certain disease conditions the vitamin c requirements are increased above normal due to an increased rate of destruction. This is particularly evident in certain infections<sup>37</sup> diseases, pregnancy, cancer, peptic ulcer and hyperthyroidism. The deficiency effects concerned with vitamin c are largely a result of the changes which are induced in certain mesenchymal cells which form the supporting structure of various body tissues.<sup>38</sup> In deficiency states the collagen intercellular substance of all fibrous tissue derivatives including that of the blood vessels, skin, cartilage, bone and teeth is altered so that there is a marked derangement in structure and function. This fundamental effect is presumed to be the underlying cause of most of the pathological changes observed in

scurvy and is particularly evident from controlled observations on body repair of traumatized tissue and wound healing. Since the latter are of ultimate surgical concern they will receive further consideration.

A wound, however inflicted, represents a solution in the continuity of tissue, and the same essential process of repair is followed in all instances beginning almost immediately after injury. At first cellular and fluid elements pass out of the blood into the injured area, with the formation of fibrinous strands which upon contraction produce a protective clot. Necrotic tissue is broken down by autolysis and carried away by phagocytic cellular elements leaving a framework of crystallized fibrin uniting the surrounding tissue. Connective tissue cells in the adjacent tissue begin a proliferative stage extending their process out along the fibrinous strands digesting and replacing the latter as they grow. With the production of increased amounts of collagenous intercellular substance new fibrous tissue is formed into which the surrounding blood vessels begin to grow. Ultimately, there results a complete replacement of the tissue defect with soft highly vascular fibrous scar. Gradually this scar undergoes contraction largely by reason of the conversion or alteration of its precollagenous elements into collagen. Surface epithelium grows in from the edges to cover the lesion and the process of repair is complete. It is this progressive conversion of the precollagen substance of the scar to collagen which gives the great tensile strength characteristic of old normal scar tissue. When there is insufficient vitamin c, the healing of the wound as a whole is profoundly disturbed. Collagen is not formed from its precursor substances and the intracellular material does not mature so that normal tensile strength is not acquired. In addition the proliferating connective tissue cells remain in a state of immaturity. Moreover it has been demonstrated that the collagen of old and normally healed wounds is reconverted to precollagen if c deficiency supervenes.<sup>38</sup>

It is obvious, therefore that vitamin c in adequate amounts is a prime requisite of normal wound healing.<sup>38-41</sup>

Other nutritional factors in wound healing must be considered in conjunction with vitamin c, particularly the indispensability of adequate serum protein. In conditions of severe hypoproteinemia the resulting edema may dangerously delay the healing process.<sup>42,43</sup> This is of particular interest in the surgery of the gastrointestinal tract where the procedures of resection and anastomosis may become extremely hazardous because of poor healing even when the actual technic is entirely above question.

From the foregoing considerations it will be seen that the indications for investigation of the vitamin c status and institution of adequate therapy are particularly urgent in: (1) All instances in which the signs of deficiency are grossly apparent;<sup>37</sup> (2) all cases in which major surgical procedures are anticipated or have already been carried out;<sup>37,44,45</sup> (3) all cases with a history of chronic gastrointestinal tract disease;<sup>46</sup> (4) cases of delayed healing for which there is no apparent cause in surgical or traumatic wounds;<sup>45</sup> (5) instances in which dietary restrictions have been voluntarily imposed as a therapeutic measure for various other diseases;<sup>46</sup> and (6) disease in which there is abnormally rapid depletion of vitamin c body content due to increased rate of breakdown.<sup>37</sup>

When no deficiency exists a daily intake of 120 mg. of ascorbic acid is adequate to provide for the highest normal requirements. Since there are no toxic consequences in giving excessive dosage, larger amounts may be given routinely. In instances of infectious diseases, neoplastic disease, chronic gastrointestinal ailments and hyperthyroidism the daily maintenance dose should be correspondingly increased. In marked deficiency states a dosage of 1,000 mg. of ascorbic acid daily for three days will produce saturation and 100 to 120 mg. is usually enough to maintain it. When such gross deficiency exists, it is expedient where possible to

examine the ascorbic blood level values at intervals as a check on the adequacy of treatment.

#### SUMMARY

Vitamin therapy is of considerable importance in the pre- and postoperative care of surgical patients.

Those of particular surgical interest are vitamins K, certain component factors of vitamin B and vitamin c because they are specifically related to the problem of nutrition and to body functions essential to normal tissue repair after surgery.

Certain aspects of the general subject of vitamin therapy have been considered.

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# THE SCIATIC SYNDROME

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LOW backache accompanied by sciatic nerve radiation of the pain, with or without actual evidence of nerve irritation, may be termed the sciatic syndrome. Since sciatic neuritis is a manifestation of some systemic diseases, such as diabetes, gout, etc., it does not fall into this category. The condition is a symptom complex, and not a diagnosis, which may be produced by any one of a number of lesions of the lower back and pelvis. The scope of this paper shall be limited to a discussion of these various lesions, and some of the differential characteristics of each will be given. No attempt will be made to enter into the treatment except for certain measures which may be of diagnostic aid. It is absolutely necessary to arrive at a fairly accurate diagnosis before rational treatment can be instituted. Treatment which is not based on a knowledge of the underlying cause, at best, cannot be adequate and most likely will be ineffective, even harmful in many instances. On the other hand, once an accurate diagnosis has been made the prognosis for an effective cure can be expected.

In order to approach intelligently the problem, one has to possess a basic knowledge of the regional anatomy and the rôle played by the various structures in the production of the disability. The symptoms and various signs accompanying them are of definite significance and one must be able to interpretate these in terms of the pathological condition involved in order to arrive at the basic cause. The failure to recognize or the ignoring of these important facts will be followed by failures in most instances.

## ANATOMIC AND PATHOLOGIC CONSIDERATIONS

The change of the human being from a quadruped to a biped and the frequent

presence of defects in the development of the low back structures have subjected the muscles, ligaments and joints of this area to strains and other lesions with radiated pain. It is true that pain in the lower back occurs more frequently without sciatic radiation of the pain than with it. However, any type of lesion in the area may produce the typical syndrome. A review of the anatomy, particularly the overlapping of the nerve supply, adequately reveals how this may occur.

The sciatic nerve arises from the fourth and fifth lumbar and the first, second and third sacral roots. Since the spinal cord ends at about the level of the first lumbar vertebra, the nerves are given off considerably higher in the canal than the point at which they make their exit. The anterior and posterior roots pierce the dura separately but join immediately afterward to compose the whole nerve root. Just after these nerves leave the canal they divide into anterior and posterior divisions. The posterior division supplies branches to the articulations, ligaments, muscles and their bony attachments. The anterior division gives off branches to supply some articulations, muscles and structures in the pelvis, but the main trunks make up the sciatic nerve. A lesion of any of the structures supplied by branches of the nerves, before joining to form the sciatic trunk, may produce reflex pain,<sup>9</sup> while pressure on the roots may produce direct nerve irritation. The former group is rarely accompanied by any objective findings.

Each of the vertebrae is jointed together by an intervertebral disc and two articular facets. The intervertebral disc is made of cartilage plates which are attached to the surfaces of the vertebral bodies above and below by a thin layer of calcified cartilage. Lying in the plates posteriorly is the nucleus pulposa. The annulus fibrosa sur-

rounds these structures and is firmly attached to both bone and epiphyseal plates by means of the Sharpey fibers. The nucleus pulposa lies beneath it, forming the anterior wall of the intervertebral portion of the spinal canal. Any condition resulting in the rupture or weakening of the annulus fibrosa may be followed by a displacement of the nucleus pulposa into the canal. The displacement is usually posterolateral on one side or the other. The displaced mass produces direct nerve pressure over the nerve root as the latter passes toward the intervertebral foramen.

The articular facets are true joints consisting of articular cartilage, synovial lining and supporting ligaments. Motion takes place in the joints as it does in all those of the diarthrodial type. These are subject to strains and other types of disturbances which may be followed by a synovitis and periarticular swelling. Since they form the posterior wall of the intervertebral foramen they lie in direct contact with the nerve root as it makes its exit from the canal. By reason of this location, pressure may be produced directly on the nerve. This occurs most frequently in the lumbosacral joint where the foramen is the smallest and the fifth lumbar nerve the largest. Muscle decompensation and ligamenture strain, resulting in an increase in the lordosis at this joint, further narrow the foramen and often produce sciatic pain by direct irritation of the nerve.<sup>1,2</sup>

The nerve supply to the capsule and supporting ligaments of the above joints and the sacroiliac joints is such that lesions affecting them may produce sciatic pain. This is also true of the ligamentous attachment of the muscles and the muscles themselves in this area.<sup>3,4,5</sup>

#### ETIOLOGY

The sciatic pain which accompanies low backache can be explained on one of two groups of causes, namely, those of reflex origin and those in which there is direct nerve irritation. Injury or disease of the structures that are supplied by the nerves

which arise from the same trunks that compose the sciatic nerve may produce a reflex sciatic pain, while lesions adjacent to the nerve roots may produce direct irritation of the nerves. The former rarely disturbs the function of the nerve while the latter often is accompanied by a decrease in reflexes, localized sensory changes and at times some muscle weakness. Therefore, any classification based on these groups would be anatomic and not etiologic. The various causes of low backache with radiation of the sciatic pain have been tabulated for the purpose of aiding one in arising at a diagnosis. Since no standard classification has been offered, the one here is based on the interpretation of findings by a few individuals.<sup>6,7</sup>

#### I. Congenital Anomalies

##### A. Anomalies of the facets and pedicles

1. Malformation and malposition of the facets
2. Separation of the neural arch (may produce spondylolisthesis)

##### B. Absence or narrowing of the lumbosacral disc

##### C. Sacralization of the fifth lumbar vertebra or lumbarization of the first sacral vertebra

##### D. Spina bifida

#### II. Trauma

##### A. Strains

1. Acute
2. Chronic
  - a. Postural
  - b. Repeated injury

##### B. Old fractures

1. Body
2. Pedicles
3. Facets
4. Lamina

##### C. Localized arthritis

1. Bodies of the vertebrae
2. Facets

##### D. Injuries to the intervertebral discs

1. Narrowing of the intervertebral disc

2. Protrusion of the nucleus pulposus into the spinal canal
3. Avulsion of the disc
- E. Hypertrophy of the ligamentum flavum
- III. Inflammatory Lesions
  - A. Arthritis
    1. Rheumatoid
    2. Spondylitis deformans
  - B. Fibrositis
  - C. Specific infections
- IV. Metabolic Lesions
  - A. Osteoarthritis
  - B. Gout
  - C. Osteoporosis
    1. Senile
    2. Disuse
    3. Hyperparathyroid disease
- V. Neoplasm
  - A. Benign
  - B. Malignant
    1. Primary
    2. Metastatic
- VI. Primary Cord Lesions
  - A. Tumors
  - B. Degenerative diseases
- VII. Malingery

#### HISTORY AND EXAMINATION

A carefully taken and thorough history is most essential to gaining an insight into the complaints of low backache with sciatic pain. This requires a careful follow-up of all the leads one can obtain while questioning the patient. Frequently the patient cannot recall anything concerning the original onset of the trouble, but by a careful checking and rechecking of all the answers one can bring out incidents which will recall the basic cause. In most cases, this one point may clarify the entire problem of diagnosis. The history of previous treatment is often helpful in solving the problem, as well as avoiding a repetition of some therapeutic measures. So often one may be prone to pass off the problem as a backache or sciatica when in reality these are only symptoms and not a diagnosis. This often results in inadequate or incorrect treatment. If, on the other hand, a thor-

ough history has been obtained, the examiner has already secured many of the data necessary to solve the problem.

In order to give the examiner a definite approach to each case, a skeletal history outline has been worked out.<sup>6</sup> This outline gives only the basic points to be analysed. Each subhead will have to be followed out separately. Each and everyone of the headings and subheadings are important. The overlooking of any one of these may mean the failure to obtain the correct insight into the specific case that is being studied. For the purpose of clarification the sciatic pain is listed under a separate heading in this outline, but the relation of this pain to the backache must always be ascertained.

- A. Age and occupation
- B. Pain
  1. Factors accompanying and preceding onset
  2. Mode of onset
  3. Duration
  4. Location
    - a. Localized
    - b. Diffuse
    - c. Radiation
  5. Type and character of pain
    - a. Continuous
    - b. Intermittent
    - c. Aching, boring, throbbing or soreness
  6. Effect of rest and activity
  7. Relation to standing
  8. Time
    - a. Continuous
    - b. Morning
    - c. End of day
    - d. Night
- C. Soreness and stiffness (if present, is it worse on arising or after activity)
- D. Feet symptoms
- E. Sciatic Pain
  1. Relation to the backache
  2. Continuous
  3. Intermittent or recurrent
    - a. Night or when lying on back with lower extremities in extension
    - b. Standing or during activity

- c. Relieved by rest
- d. Effect of coughing or sneezing
- 4. Tiring or difficulty when walking
- 5. Bowel and bladder disturbances
- F. Symptoms relative to remote structures and their relation to the back-ache
- G. Previous therapy

A complete routine examination should be carried out on every patient. Before beginning the examination, the patient must be completely disrobed, including the removal of the shoes and stockings. The female patient may be draped but the entire back and lower extremities should be exposed. It is most important for a complete general examination to precede that of the back. At this time special attention is given to the teeth, tonsils, lower gastrointestinal tract, genital organs and urinary tract. Infection in these structures may be the cause of an arthritis, or a minor disturbance in them may produce a reflex type of pain. However, the latter is a rare occurrence. Tumors in the pelvis, bladder and rectal area are important in that they may produce the same type of pain or they may involve the spine or nerve by extension. The actual physical study of the back begins as soon as the patient enters the office. By doing this one can often obtain valuable information when the patient is not aware that he is being observed. This is particularly true in the malingerer.

Upon beginning the examination the patient is asked to walk, stoop, walk on the heels and the toes, hop and squat, during which time one notes the disturbance in posture, gait and impaired muscle function. Following this the back and lower extremities should be examined in the standing, sitting and both the prone and supine positions. The latter phase of the examination should be carried out on a firm table that is long enough for the patient to stretch out comfortably. The following general outline has been found to be of aid in observing and tabulating the findings:

- 1. General posture
- 2. Gait

- 3. Contour of the back
  - a. Normal
  - b. Kyphosis
  - c. Lordosis
  - d. Lateral curvature
    - (1) Scoliosis
    - (2) Lateral deviation or what is generally termed "sciatic scoliosis"
- 4. General protection of the back in moving
- 5. Tenderness
  - a. Location
  - b. Localized or diffused
  - c. Degree of severity
  - d. Whether or not eliciting it reproduces back or sciatic pain
- 6. Muscle spasm
- 7. Spinal motions
  - a. Guarded
  - b. Actual restrictions
  - c. Does eliciting the motion reproduce the back or referred pain.
- 8. Gaenslen's test for sacroiliac disease
- 9. Patrick's sign
- 10. Ober's test for shortening or spasm of the tensor fascia lata<sup>3</sup>
- 11. Straight leg raising test
- 12. Prone trust test<sup>9</sup>
- 13. Trigger point test<sup>5</sup>
- 14. Evidence of sciatic nerve involvement
  - a. Tenderness
  - b. Positive Lasegue's sign
  - c. Decreased or absence of the Achilles tendon response
  - d. Muscle weakness and atrophy
  - e. Sensory changes

The major symptoms and physical findings in the sciatic syndrome are so frequently observed that a brief elaboration of them has been thought to be of some value.

*Pain.* Pain in the lower portion of the back is present in all cases with radiation to the buttock, posterior thigh and then down the course of the peroneal nerve or it passes down the outer side of the leg and to the foot. The back pain may be a constant dull ache, a sudden catch upon any motion or a

combination of the two. The sciatic pain may be continuous, intermittent or it may be present only on sudden motion and lasting for just a short period.

*Posture.* The back may be straight with good motion in all directions; however, forward bending is limited in most instances because it produces some tension on the nerve trunks. There may be an increase in the forward lumbar curve producing the so-called "sway back." This is seen more frequently in women with relaxed and weak muscles. There may be a list to one side or the other, the so-called sciatic scoliosis. More often the list is away from the painful side and is accompanied by slight flexion at the hips. When present, attempts to bend to the opposite side or to straighten up increases both the back and referred pain.

*Signs and Tests.* 1. *Prone Thrust Sign.*<sup>9</sup> The patient lies prone, raises himself on his hands with the elbows extended, dropping the pelvis toward the table as far as possible. This produces hyperextension of the spine with the strain centered in the lumbosacral area.

2. *Gaenslen's Test.*<sup>8</sup> The test is elicited with the patient in the supine position and the painful side to the edge of the table. The thigh of the well extremity is forcibly flexed on the abdomen to fix the lumbosacral joint. The other extremity is then dropped over the side of the table and slight forced hyperextension at the hip is carried out. The reproduction of the pain in the sacroiliac area suggests involvement of this joint. It is believed that this is one of the most reliable tests.

3. *Patrick's Sign.* The forced abduction of the flexed thigh produces pain in the sacroiliac region. The test allows some rotation at the lumbosacral joint; thus its value as a diagnostic test of sacroiliac joint involvement is questioned.

4. *Ober's Test.* Ober's test is indicative of shortening of the iliotibial band. It consists of an attempt to adduct the abducted extended thigh with the knee flexed and the extremity supported only by the foot. The

test is carried out with the patient lying on the side. The failure of the knee to drop down to the table indicates some shortening of the muscle.

5. *Trigger Point Test of Steindler.* The presence of a localized point of tenderness, which when injected with novocain produces relief of the radiated and local pain, indicates a local ligamentous or muscle strain.

6. *Straight Leg Raising Test.* The lower extremity is flexed at the hip with the knee extended, producing pain in the hamstring and lumbosacral area. The extension of the lordosed lumbosacral joint by the tense hamstring muscles offers the best explanation for the pain.

7. *Lasègue's Test.* The thigh is flexed to right angles. The leg is extended on the thigh until pain begins in the buttock or posterior thigh region. No further movement of the thigh or leg is carried out, but the foot is then dorsoflexed. The latter phase of the test increases the tension on the sciatic nerve without moving or putting any further strain on the hip or lumbosacral spine. If the pain is increased in the course of the sciatic nerve, the test is considered positive. This test should be definitely differentiated from the so-called straight leg raising test because it only places tension on the sciatic nerve while the latter also increases the strain on the low back structures.

8. *Muscle weakness, sensory changes and decreased reflexes will be found localized to the dermatomes which have been involved.* The presence of these signs indicate pressure on the sciatic nerve or the roots from which it arises.

9. *Tenderness in the lower back is of importance because of the manner in which it has to be elicited.* When jarring is required to elicit it the source is usually in the bone or joint structures. If pain is produced in the sciatic nerve area by applying deep pressure to the involved side of the suspected vertebra, one suspects a ruptured nucleus pulposa. Tenderness over the ligamentous attachments about the poste-

rior lower back area is significant if the pain is relieved by a local infiltration with novocain.

*Special Examinations.* 1. *Roentgenologic Examinations.* The physical examination should be followed by routine stereo-anteroposterior and lateral x-ray films of the lower back. If one suspects a lesion of the facets, the views should be supplemented by films in both oblique positions. In the x-ray one has a valuable aid in the diagnosis of many lesions, but if one depends on it for the diagnosis he will encounter many pitfalls. The interpretation of the findings and the correlation of them with the clinical findings are absolutely essential and require a knowledge of the variations in the skeletal structure of the lower back as well as the pathologic bone changes which may occur in this area. Ghormley<sup>11</sup> has tabulated these changes in detail.

2. *Spinal Puncture.* A spinal puncture should be performed on every patient in whom the clinical findings indicate a lesion inside the spinal canal and also on those patients in whom one suspects such a lesion when no other cause can be found. The puncture should be performed as low in the canal as possible, usually between the fifth lumbar and the first sacral vertebrae. A partial block in a lesion above this level can often be demonstrated. The removal of the fluid from the immediate area of the lesion, which is facilitated by the low puncture, is useful in showing the total protein elevation. This is explained on the basis that the increased protein in the spinal fluid is dependent upon circulatory disturbances and they are greatest in the immediate vicinity of the lesion.<sup>11</sup>

3. *Spinogram.* The instillation of any material into the spinal canal should be reserved solely for the purpose of localizing the lesion. Therefore, it must always be preceded by a positive clinical diagnosis. The technic now used by many surgeons is that of instilling air into the canal, because many of them believe that the presence of iodized oil in the canal produces some

arachnoid irritation. Bradford and Spurling believe that this is not the case. They are of the opinion that the injection of a small quantity (2 cm.) of undeteriorated oil in the canal does not produce any irritation. The oil is a much more satisfactory aid to the diagnosis. The difficulty often encountered in visualizing the canal with air, together with the fact that it is more likely to be used in cases in which there are no definite indications for a spinogram, are logical reasons for not using it.

#### DIFFERENTIAL DIAGNOSIS

The differential diagnosis of low back pain accompanied by radiation of the pain to the distribution of the sciatic nerve presents many complex problems. Some lesions produce very definite and characteristic findings, while in others the symptoms and signs are so vague that a solution cannot be made even by the most experienced investigator. With the full realization of these facts, an attempt has been made to list the characteristics of the various groups of lesions.

*Congenital Anomalies.* Much significance has been placed on congenital anomalies as a cause of backache. When present they are evident enough to cause very little difficulty in arriving at a diagnosis. The roentgenologic findings are definite in this type of lesion. The problem is to be sure that such a lesion, even though present, is the cause of the symptoms.

*Strains.* The postural strains are characterized in the early stages by an aching and tired feeling while standing which is relieved by activity, gradually progressing until the pain is constant and accompanied by sciatic radiation. There is a lumbar lordosis with soft, flabby muscles while the majority of other findings are absent. Often, the etiologic factor, particularly in women, will be ill-fitting shoes. Thus, the feet are of sufficient importance to be always included in the examination. Strains resulting from injury usually are aggravated by activity. The pain is practically always localized to the structures under

strain. Active contraction of the involved muscles or passive stretching of the ligaments and ligamentous attachments will reproduce the pain. The injection of novocain into the localized area will relieve the referred as well as the local pain.

*Traumatic Arthritis and Old Fractures.* A history that injury initiated the symptoms can be obtained in nearly all cases. The pain is localized and it is aggravated by activity. When sciatic nerve radiation of the pain is present, it may signify that bony or scar tissue impingement of the nerve root or the actual compression of herniated nucleus pulposa is the cause.

*Herniation of the Nucleus Pulposa.* Trauma to the back, even though mild, followed by persistent or recurrent pain in the lower part of the back with sciatic radiation of the pain which increases with activity, suggest a herniation of the nucleus pulposa. The diagnosis can be made when this picture is accompanied by a diminished or absent Achilles tendon response, sensory changes and an increased concentration of protein in the cerebral spinal fluid. The above findings are indications for performing a spinogram to localize the lesion.

*Hypertrophy of the Ligamentum Flavum.* The clinical pictures produced by a hypertrophy of the ligamentum flavum and herniation of the nucleus pulposa are identical. The spinogram may show the posterior rather than the anterolateral defect, but since they occur together very frequently the differential diagnosis cannot be made before exploration.

*Tumors of the Cauda Equina.* Cord tumors in the lumbar region often simulate herniation of the nucleus pulposa. However, the pain is usually persistent and progressive, increased at night or during rest and often relieved by activity. The findings resulting from nerve compression are more widespread, for example, muscle weakness, atrophy, sensory changes, reflex changes, etc.

*Inflammatory Lesions.* Pain in the back characterized by an onset of soreness and

stiffness on arising in the morning which subside with activity only to recur with rest is characteristic of an inflammatory process. The condition may involve the joints, ligamentous structures and muscles of the back. The tissues involved will determine the location of the pain. Muscle spasm and rigidity accompany the pain. Limitation of chest expansion often gives a clue to the solution of the problem. The condition will often be precipitated by an acute upper respiratory or other regional infection. Sciatic radiation of the pain may be present and exhibit all the characteristics of compression. The characteristic history and findings will differentiate the conditions. Lesions resulting from specific types of infection can usually be recognized by the roentgenogram and by positive laboratory data. Tuberculosis produces a destructive lesion, accompanied by a paravertebral abscess which may produce psoas muscle irritation. Malta fever presents a picture of a destructive arthritis usually without a paravertebral shadow. The agglutination or intradermal test will indicate the presence or absence of the infection.

*Metabolic Lesions: Osteoarthritis.* Osteoarthritis rarely will produce sciatic pain by means of direct irritation of the root by a large spur. The symptoms are present on activity and subside with rest. Rarely are any objective nerve findings present. The presence of a large spur corresponding to the root pain in the absence of any other cause makes the diagnosis.

*Gout.* Recently attention has been focused on gout. The picture may be that of an acute onset subsiding in a few days with periodic recurrence, or it may simulate the usual infection group. The elevation of the blood uric acid and the response to the diagnostotherapeutic test indicate its presence.

*Osteoporosis.* Osteoporosis of the spine nearly always produces backache. If the softening of the bone is sufficient to allow some compression of the vertebral bodies, there will be some disturbance of the articular facets and possibly some narrow-

ing of the intervertebral foramen. Either of these may produce sciatic pain. The pain will be increased by activity and relieved by rest. There is marked diffuse tenderness on jarring and back motion is limited. The condition is found most frequently in debilitated and elderly persons; however, those cases which are manifestations of hyperparathyroid disease may be found in young people. The diagnosis of the whole group can be made by the roentgenogram while the blood chemistry is of primary importance in differentiating the hyperparathyroid group.

**Neoplasms.** The benign tumors will cause little concern because they can always be diagnosed by the roentgenogram. Malignant tumors, on the other hand, may confuse one, especially in the early stages because at this time there may not be any radiologic evidence of changes in the bone. When persistent night pain is present for which no skeletal origin can be found, when the neurologic examination is negative and when the condition does not respond to the usual forms of treatment, one must consider the presence of a malignant neoplasm. A recheck of the patient after a few months will often reveal the nature of the lesion to be a malignant tumor.

**Remote Causes.** Minor disturbances of the pelvic organs in both the male and female rarely cause back pain. However, they are the cause just frequently enough so that one has to consider them when arriving at a diagnosis. Pain with its origin in the pelvis is most often referred to the center of the sacrum and sacroiliac joints, radiating to the distribution of the sciatic nerve. Tumors in the pelvis may, by means of their size and location, produce pressure

directly on the sacral plexus. When this occurs they may simulate any of the various causes of the syndrome. The diagnosis can be made by a careful pelvic and rectal examination.

**Malingery.** The malingerer frequently presents a diagnostic problem. Careful observation during the whole course of the examination will often expose these individuals. Their lack of anatomic knowledge makes it nearly impossible for them to fake an organic lesion. Almost invariably the findings are far more extensive than could be produced by any disease process. The symptoms and findings will not follow the pattern of any organic lesion.

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# LYMPHADENOPATHY OF THE NECK

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IN considering lymphadenopathy of the neck it is necessary to take into account various conditions which may cause or be mistaken for enlargement of these lymph-nodes. These conditions have

TABLE I

CONDITIONS SIMULATING OR CAUSING ENLARGEMENT OF  
THE LYMPH NODES OF THE NECK

Cystic tumors
Branchial cysts
Thyroglossal cysts
Cystic hygroma
Dermoid cyst
Vascular lesions
Aneurysm
Angioma
Inflammatory lesions
Syphilis
Tuberculosis
Acute suppuration
Woody phlegmon
Actinomycosis
Blastomycosis
Infectious mononucleosis
Solid tumors
Benign tumors
Lipoma
Mikulicz's disease
Adenoma of thyroid gland
Malignant tumors
Metastatic carcinoma
Carcinoma of thyroid gland
Adenocarcinoma of submaxillary gland
Tumor of carotid body
Lymphoma
Hodgkin's disease
Lymphosarcoma
Lymphatic leukemia
Leukemic reticulo-endotheliosis

been listed in Table I and also will be considered under separate headings.

## LIPOMA

A lipoma usually is rather soft and it is poorly defined. Often, on careful palpation, the lobules of the tumor can be felt. Usually, there is a history that the mass has been present without material change for a long time, often for years.

## MIKULICZ'S DISEASE

Mikulicz's disease is a process of lymphocytic replacement of the glandular structure of the salivary and lachrymal glands. This causes the glands to become enlarged and firm. If the submaxillary glands in the neck are enlarged and firm and if the parotid and lachrymal glands present evidence of similar induration and enlargement, the presence of Mikulicz's disease must be considered.

## ADENOMA OF THE THYROID GLAND

Adenoma of the thyroid gland ordinarily need cause little confusion because it usually is in a lobe of the thyroid. Occasionally, however, an adenoma may be found in an unusual situation and may closely simulate an enlarged lymph-node. The most common atypical site is in the region overlying the thyroid cartilage. This is above the isthmus and is in the region where metastasis of carcinoma of the larynx may be found.

## PARAFFINOMA

A rare cause of a nodule in the neck is paraffinoma. Paraffin is sometimes injected subcutaneously for the correction of facial deformities, particularly wrinkles and depressions. This material may migrate down into the neck and lead to the formation of firm fibrous nodules. On palpation, these are likely to resemble none of the conditions commonly encountered and this fact may serve as a clue so that careful questioning may bring out the fact that paraffin has been injected for cosmetic purposes.

## BRANCHIAL CYSTS

A branchial cyst usually is a perfectly smooth globular mass situated in the

midcervical region just anterior to the sternomastoid muscle. Its cystic character usually can be made out on palpation but sometimes it is so tense that it feels like a firm lymph-node. If the cyst has drained spontaneously or has been drained surgically, there may be a draining sinus leading to an indurated region. The condition then may resemble tuberculous adenitis. Careful palpation will reveal a cord-like structure leading from the sinus to the region of induration. This is not characteristic of any other condition (except for some thyroglossal cysts).

#### THYROGLOSSAL CYSTS

A thyroglossal cyst differs from a branchial cyst chiefly in situation. It is found in the median line overlying the thyrohyoid membrane. If intact, it has the same characteristics on palpation as a branchial cyst. There may be a draining sinus (sometimes opening as low as the suprasternal notch) and a palpable cord-like structure leading to the middle of the hyoid bone.

#### CYSTIC HYGROMA

Cystic hygroma is a tumor made up of multiple cysts which have thin walls and are filled with lymph. If not infected, it is very soft and easily compressible. If it is infected, it may be very tense, the overlying skin is usually red and the patient is likely to appear acutely ill because of the ready absorption of toxic material from the thin-walled structures making up the tumor.

#### DERMOID CYSTS

Dermoid cysts occasionally occur in the floor of the mouth and produce a mass visible and palpable in the submaxillary region. Characteristic features are the very slow progression and the fact that on bimanual palpation a distinctly doughy sensation is noted.

#### ANEURYSM

An aneurysm of one of the large vessels of the neck is a rare condition but should

present no great diagnostic difficulties. It is a fairly tense but compressible pulsating tumor over which a bruit can be heard. In patients, who are thin and elderly, the carotid artery just below its bifurcation may be bulbous or slightly tortuous. This finding is sometimes mistaken for aneurysm or even for an enlarged lymph-node.

#### ANGIOMA

An angioma of the neck which is deeply situated and does not involve the overlying skin will not produce the discoloration usually characteristic of angioma. There are no symptoms unless the tumor is very large. On palpation, such a lesion is soft, easily compressible and is very poorly defined. No bruit is to be heard on auscultation over the lesion. Usually, the tumor becomes noticeably larger when the patient's head is placed in a dependent position. It may be difficult to differentiate between cystic hygroma and angioma. The former tends to be softer and more easily compressible than the latter.

#### SYPHILIS

Syphilis often is a cause for enlarged lymph-nodes in the neck. In primary syphilis, when the initial lesion is situated about the mouth or throat, enlarged lymph-nodes always are present in the neck. In cases of secondary syphilis they may be present in the neck as part of a general adenopathy. If there are any secondary lesions about the oral cavities, cervical adenopathy is almost certain to be present. In tertiary syphilis, unilateral cervical adenopathy is occasionally found. The enlarged gland usually is very firm and simulates a metastatic malignant lesion. If serologic tests are positive and if there are no other findings to account for enlarged lymph-nodes in the neck, a therapeutic test may be indicated. Unless the response is very prompt, some other explanation for the adenopathy must be sought irrespective of a positive serologic reaction.

## TUBERCULOUS CERVICAL ADENITIS

Tuberculous cervical adenitis may be encountered at any age. The disease usually is unilateral and it may or may not be associated with draining sinuses. If sinuses are present, the history usually will reveal that the enlargement had occurred gradually and that softening and redness had been present for two weeks or more before the lymph-node drained spontaneously or was drained surgically. In cases in which the lymph-nodes do not break down, there usually is a history of enlargement and recession. The lymph-nodes tend to enlarge when the patient has a cold or some other condition which reduces his resistance. They tend to recede again as the general health improves. Tuberculous adenitis may be present in the neck when there is no demonstrable evidence of tuberculosis elsewhere in the body. Biopsy is necessary to make a positive diagnosis.

## ACUTE SUPPURATIVE CERVICAL ADENITIS

Acute suppurative cervical adenitis usually causes little difficulty in the matter of diagnosis. Enlarged lymph-nodes in the neck, often unilaterally situated or larger on one side than on the other, appearing with or soon after an inflammatory process about the oropharynx, are likely to be the result of secondary inflammation. This condition is seen most frequently among children. The course of events usually removes any doubt as to the diagnosis. Resolution may take place but suppuration often occurs and drainage is necessary. Usually, one or the other course is evident within a few days.

## WOODY PHLEGMON

Very rarely the acute suppurative adenitis becomes indolent and results in a condition known as woody phlegmon. In this condition the patient has an indurated mass in the submaxillary region or neck (or both), which may remain virtually unchanged for weeks or months. Usually, resolution without suppuration finally occurs.

## ACTINOMYCOSIS

In actinomycosis a slowly progressive induration appears usually in the submaxillary or parotid region and very often it is associated with more or less ankylosis of the mandible. Frequently, there is a history of extraction of a tooth or of some other trauma within the mouth, usually a month or more before the appearance of the present symptoms and signs. In short, if the patient has what seems to be an inflammatory induration in the vicinity of the jaw, the duration of which is three weeks or more, and if there is an associated ankylosis of the mandible, the possibility of actinomycosis must be very seriously entertained. Microscopic examination of pus from a freshly opened pustule or abscess for the demonstration of the characteristic granules or mycelia is necessary to establish the diagnosis. It may be necessary to make repeated examinations before a positive smear is found. The organisms are cultured with difficulty.

## BLASTOMYCOSIS

Blastomycosis is one of the rare causes of enlargement of the cervical lymph-nodes. Lesions of the mucous membrane, from which the disease may metastasize to the lymph-nodes, are granulomatous in appearance and have on their surface scattered tiny yellowish pustules. Skin lesions also are granulomatous and often crusted. If a specimen of a suspected lesion is removed for biopsy, the pathologist should be advised as to the suspicion because the characteristic double refractive organisms easily may be missed unless special care is used in searching for them.

## METASTATIC MALIGNANT LESIONS

The physician must always be on the alert for metastatic malignant lesions as a cause of enlarged lymph-nodes in the neck. When found they usually are secondary to a primary lesion on the lip or in the mouth or throat. Metastatic involvement of the lymph-nodes by a malignant lesion produces a very characteristic sensation of

firmness when palpated so that the experienced physician can predict with a high degree of accuracy whether or not palpable lymph-nodes are the site of malignant metastasis.

Metastatic involvement of the cervical lymph-nodes by carcinoma of the lower lip, cheek or lower jaw is found most frequently in the submaxillary region. Metastasis of carcinoma of the tongue, hypopharynx or tonsillar region most frequently occurs deep in the carotid triangle of the neck. Carcinoma of the larynx most frequently metastasizes to lymph-nodes overlying the bifurcation of the carotid artery. Carcinoma of the nasopharynx may metastasize to the lymph-nodes in the carotid triangle of the neck or deep under the upper third of the sternomastoid muscle. When suspiciously firm lymph-nodes are found in any of these situations, careful search for a primary lesion must be made in all portions of the oral and nasal cavities. In the case of elderly patients, one must consider the possibility that metastatic involvement of a lymph-node in the neck may be secondary to "skin cancer." These lesions, particularly those in the preauricular region, sometimes are active squamous cell carcinomas and may metastasize. If no malignant lesion is found, the patient must be questioned carefully as to whether he has had treatment for a lesion in any of these regions. The patient may have had a sore on his lip several years previously, for which he had been given "light treatments" and he may be totally unaware that the lesion had been believed to be cancer and that he really had received roentgen therapy. Even in cases in which there is an obvious scar, the patient, when first questioned, may forget that he had ever had a lesion treated. One also must remember that there is a tendency among too many physicians to "try some x-ray treatment and see what happens." In some instances this therapy may result in the disappearance of the primary lesion without material effect on the metastatic in-

volvement of the nodes. Biopsy of a suspected node may be the only means of reaching a decision.

Metastatic involvement of the lymph-nodes in the neck secondary to primary lesions in sites other than the oral cavities, such as the esophagus, stomach or breast, is likely to be found just above the clavicle. Suspicious lymph-nodes low in the neck should arouse suspicion and lead to investigation of these structures.

#### CARCINOMA OF THE THYROID GLAND

Carcinoma of the thyroid should cause no great diagnostic difficulties because of the situation of the characteristically firm mass which involves the gland and is fixed within it. If there is associated paralysis of a vocal cord it is almost certain that the suspected tumor is malignant.

A carcinoma of the thyroid gland may be very small yet give rise to metastatic involvement of the lymph-nodes. The involved lymph-nodes usually are found adjacent to and just posterior to the affected lobe of the thyroid gland. Usually the primary lesion can be felt on palpation but even if it is not palpable the site of the metastatic involvement of the lymph-nodes is sufficient ground for suspicion.

#### ADENOCARCINOMA OF THE SUBMAXILLARY GLAND

Adenocarcinoma of the submaxillary gland causes a tumor palpable in the submaxillary triangle. It may be impossible to distinguish it from metastatic involvement of a lymph-node although its location at the site of the submaxillary gland together with the fact that the gland itself cannot be palpated is cause for strong suspicion. It should be remembered, however, that when a stone obstructs the duct of the submaxillary gland infection occurs in the submaxillary gland and the infected gland feels stony hard on palpation. Consequently, stone in the duct should be ruled out as a possible cause for an enlarged, very firm submaxillary gland.

### CAROTID BODY TUMOR

Carotid body tumor is a rare cause of swelling in the region of the bifurcation of the carotid artery. This tumor is very rarely susceptible to diagnosis preoperatively. It is attached in the bifurcation of the carotid artery and if a firm tumor is found in this situation which is movable to and fro but not movable up and down, one is entitled to suspect this lesion.

### HODGKIN'S DISEASE

Lymphadenopathy associated with Hodgkin's disease most frequently occurs in the cervical region and early in the disease the involvement usually is unilateral. A solitary lymph-node or several nodes may be involved and the size of the nodes may vary. The nodes are firm and somewhat matted together. In general, early in the disease the patient is not particularly ill and usually consults a physician because of cervical adenopathy. In the early stage, an important point in the differential diagnosis of Hodgkin's disease, lymphatic leukemia and lymphosarcoma is the fact that in Hodgkin's disease the involvement of the lymph-nodes generally is unilateral. In leukemia and lymphosarcoma the involvement is symmetrical and splenomegaly usually is present. In our experience it is very rare to find an enlarged spleen early in Hodgkin's disease but in the late stages of the condition the spleen frequently is palpable. The diagnosis usually can be established by excision of a lymph-node and examination of the fixed tissue. There is no characteristic blood picture although late in the disease there usually is polymorphonuclear leukocytosis with associated monocytosis, but since this same picture may occur in many other conditions it can under no circumstances be considered as diagnostic.

### LYMPHATIC LEUKEMIA

In lymphatic leukemia and leukemic reticulo-endotheliosis, including the Schilling type of monocytic leukemia, the lymph-nodes usually are discrete and

involve both sides of the neck symmetrically. In the chronic forms, in addition to cervical adenopathy there usually is generalized, symmetrical, peripheral lymphadenopathy. The spleen usually is enlarged and in some instances may be of enormous size, out of all proportion to the degree of involvement of the peripheral lymph-nodes. The liver likewise is enlarged in most cases. In acute leukemia the lymph-nodes may enlarge rapidly and hemorrhage frequently occurs from the mucous membranes owing to a decrease in the number of blood platelets. Occasionally, in very acute leukemia, lymphadenopathy may be slight and the patient may consult his physician because of hemorrhagic manifestations or ulceration of the mucous membrane of the mouth. In addition, anemia of severe degree frequently accompanies acute leukemia and there is an associated fever. The diagnosis of leukemia usually is made by presence of an elevated leukocyte count and high percentage of immature lymphocytes. It must be borne in mind that in acute leukemia the total leukocyte count not infrequently may be less than 10,000, but on examination of a blood smear a high proportion of stem cells will be found. Leukemic reticulo-endotheliosis usually is readily identified by examination of a blood smear which reveals various stages of the development of reticulo-endothelial cells into lymphocytes. The typical reticulo-endothelial cell is a large cell with abundant cytoplasm and a round nucleus with one or more nucleoli. Chromatin strands are sharply differentiated from the parachromatin and usually extend transversely across the lesser diameter of the nucleus. Frequently, these chromatin strands are bent toward the central portion of the nucleus, giving the appearance of a longitudinal groove. In the stages of development from this cell to the lymphocyte, there is gradual rounding of the cell as a whole with concentration of chromatin and loss of nucleoli, but the grooving persists practically to the mature cell. In the acute forms

of the disease, many mature lymphocytes will be found. Removal of a lymph-node for examination of fixed tissue is necessary for the differential diagnosis of lymphosarcoma. The Schilling type of monocytic leukemia is quite similar to leukemic reticulo-endotheliosis. The diagnosis usually can be established by examination of a fixed blood smear where it is found that the reticulo-endothelial cell is developing into a monocyte rather than into a lymphocyte.

#### INFECTIOUS MONONUCLEOSIS

From the standpoint of adenopathy, infectious mononucleosis presents essentially the same clinical picture as leukemia or lymphosarcoma. The involved lymph-nodes are discrete and usually are bilateral and symmetrical. They frequently are quite tender to palpation and may increase in size at great rapidity. As a rule, the course of this disease is relatively mild but at times the clinical picture may

simulate that of fulminating, acute leukemia. The diagnosis may be suspected from examination of leukocyte and differential counts and the absence of anemia. The leukocyte count rarely is higher than 40,000 or 50,000, and the percentage of lymphocytes in the differential count usually is less than 80, whereas in leukemia the percentage of lymphocytes is generally 90 or more. Examination of a blood smear is an essential diagnostic aid. Practically all lymphocytes are mature although the cells may be somewhat altered in size and may have a foamy type of cytoplasm with bizarre-shaped nucleoli, so-called leukocytoid forms of lymphocytes. Examination of these cells shows that they are not immature but are usually a variant of a perfectly mature lymphocyte. Occasionally, slight immaturity may be found but the general picture is that of a rather benign process. Infectious mononucleosis is almost invariably a benign process and treatment is palliative.



# DIAGNOSIS IN CONVULSIONS\*

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THE mystery and superstition that has clung to the problem of convulsive seizures since the earliest human records has largely been dispelled during the past two decades.

A new point of view and interest has arisen within the profession since the demonstration of the beneficial effects of convulsions in the treatment of mental disease. It is now possible to produce a convulsion at any time, in any person, by the simple snap of a switch (electric shock); or injection of the appropriate dose of convulsant drug (Metrazol).

Tests have been devised to bring out in the open, latent convulsant tendencies in the patient by means of hyperventilation (Rosette), insulin-hypoglycemia (Sakel); or by the forcing of liquids, after renal suppression with pitressin (Fremont-Smith, McQuarrie).

With this recent intimate knowledge regarding convulsions and the ability to initiate or control an attack, it is apparent that the *diagnosis of convulsive seizures* must be considered from an entirely different point of view than that formerly taught and held by the profession.

Reluctance on the part of the profession to render a prompt diagnosis and classification when convulsive seizures are encountered, stems partly from fear that the seizure may be associated with some form of "epilepsy," and partly from confusion as to the proper term to apply, when such a symptom appears for the first time in the history of the patient.

Lack of specific knowledge as to etiology, as well as disagreement amongst authorities as to terminology, prognosis and treatment, has permitted the public to retain the superstitions of the past, (often shared

by the physician himself) which implied "hereditary taint," family disgrace and future mental deterioration if the diagnosis of epilepsy was made. The profession and public alike have been unwilling to face the truth in the early period of the onset of symptoms, when much could be done to control the attacks and prevent undesirable progress and sequelae.

Multiplicity of terms for the problem under consideration only adds to the uncertainty and confusion. The reader, if he prefers, may select (and with good authority) any one of the following: *The sacred disease* (Hippocrates), *disease of Hercules* (Greek), *falling disease* (Hebrew), *morbus comitialis* (Roman), *epilepsy* (Avicenna?), *grand mal* (French), *spectrum of epilepsy* (Foster Kennedy), *convulsive state* (Lennox and Cobb), *cerebral dysrhythmia* (Lennox), *convulsions*, *seizures*, *attacks* and *fits* (Vulgar).

Although agreement as to terminology has not been reached as yet by the authorities, it is well recognized today that *epilepsy is not a disease* and convulsions, whether single or recurrent, constitute merely a *symptom complex* inherent to the nervous system, not unlike so-called "reactions of defense," (vomiting, shivering, spasms of coughing, involuntary reactions to fright, pain, etc.).

As a *symptom complex*, it must be expected to have variable manifestations. It is obvious that one cannot "cure" a *symptom complex* as they would a *disease*. Rather, it is necessary to seek to *control* such a mechanism or break it down into its component parts, in the hope that we may prevent one or more of the units from entering into the appropriate convulsive "combinations" leading to a seizure.

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Our Clinic has been inclined to favor Foster Kennedy's idea of a "Spectrum of Epilepsy": The convulsive state may be so arranged that there exists a gradual shading of attacks from the *larval types* at the one extreme to the full-blown *major seizure* at the other. Some of these attack patterns are characteristic and easily recognized; others assume transition forms and combinations that often make them difficult of diagnosis and classification. (Table 1.)

The term *convulsive state* should include all types and forms of seizures, and, as long as an attempt is being made to get away from the word "epilepsy," this term seems to be a broad and satisfactory compromise. If escape from the ancient superstitions and fears surrounding the name of epilepsy alone were the object, it would seem better perhaps to adopt the simple, vulgar, but descriptive designation of a "fit," as it is frequently associated with other less fearful states such as "fits of laughter" and "fits of rage."

The most recent name suggested is the term *cerebral dysrhythmia*. Dysrhythmia refers to abnormal types of electrical brain waves with characteristic "spikes" and "frequencies" recorded by the electroencephalograph. The instrument is valuable in definitely differentiating between the four fundamental types of the convulsive state:

1. Larval state (psychic)
2. Petit mal
3. Jacksonian fits
4. Grand mal

As abnormal brain waves are also found in normal individuals during sleep, after hyperventilation, and as a result of disturbed sugar metabolism of the brain cells, it is obvious that nothing in the nature of pathognomonic evidence of epilepsy has been established. Where more than twenty individuals will manifest dysrhythmia, only one is afflicted with true convulsive attacks (and convulsive attacks occasionally arise or can be induced in normal individuals), so

TABLE I

THE CONVULSIVE STATE  
(Symptomatic Progression)

Normal Integrated Level of Control

Unfavorable Progression of Symptoms ↓ Favorable Improvement and Control of Symptoms ↑	Larval attacks (Psychic equivalent)	}	Aura; visual, auditory, olfactory, gustatory, vertiginous, epigastric
			Viscero-motor, pilomotor, vascular episodes
			Dreamy states, lapse, absence
			Psychomotor (sudden altered behavior)
			Recurrent amnesia and automatism
			Vacant spells; suspended mental activity
		→	
	Minor seizures (Petit mal)	}	Sudden transient unconsciousness. Micturition; objects dropped
			Temporary arrest of activity or movement
			Dilatation of pupils, pallor, staring
			Conjugate movement of eyes, turning head
			Sucking, champing, swallowing, vocalization
			Twitching face, arms, fingers, extremities
		→	
	Jacksonian attacks (Focal fits)	}	Falling (loss of "antigravity" muscle control)
			Full loss of consciousness (syncope)
			Rigid tonic phase, cyanosis, trismus
			Breath held (decerebrate rigidity)
			Clonic rhythmic movements of large flexor-extensor muscles
			Selective motor pattern unaltered by age or training
			Breathing re-established—stertorous type
			Cessation of movement—relaxation
		→	
	Major seizures (Grand mal)	}	Stupor (micturition, defecation, sweating, vomiting)
			Sleep followed by dull mental state
			Headache
			Mental deterioration



that it becomes obvious that further extended analysis, clarification, and research will have to be carried on before the designation of *cerebral dysrhythmia* can be reserved to the epileptic; or that the many others who show the "typical spikes" of dysrhythmia, but without seizures, can be proved to be "potentially" epileptic.

If the convulsive state may be considered analogous to a "spectrum of light" as Foster Kennedy pointed out, it is only of academic interest to name and classify the endless shades in the one, or the varieties of attacks possible in the other.

*Diagnosis* in the past has too frequently concerned itself with controversial borderline classifications, rather than attempting to establish a basis for therapeutic relief in the problem that confronts us today. There are, however, certain *common denominators* that underly the majority of seizures and should be sought for so that enlightened diagnostic and therapeutic considerations can be directed at the *source of trouble* rather than adopting blindly palliative sedation designed to conceal the progression of symptoms after they have finally developed.

*Diagnosis in convulsions* should concern itself not only with the distinguishing characteristics that separate the convulsive state from other conditions, but also with classification of its own types. Careful appraisal of certain *structural deviations* most commonly encountered in the physical make-up of those who suffer from so-called essential (idiopathic) seizures should be included in the field of survey. Thus the *diagnosis* of a *structural inadequacy* may offer a clue to certain contributory factors related to these seizures, whereas, designation of the condition as an "essential epilepsy" merely surrenders the problem into the realm of ignorance and despair.

Recently it has been realized that correction of certain common *structural inadequacies* of the chest and cardiovascular mechanism (through carefully planned exercise) has led to definite improvement in the patient and better control of the

seizure, (more efficient cardiocerebral circulation, increase in carbon dioxide reserve).

#### DIFFERENTIAL DIAGNOSIS

True convulsive seizures are easily recognized even in their rudimentary patterns. Diagnosis chiefly concerns classification of types arising in the borderline groups of the *larval forms*. Here, sudden alteration of behavior, temper tantrums and violent emotional storms are occasionally believed to be "psychic equivalents" of a seizure and must be differentiated from purely psychopathic states. Careful observation of the patient is required to ascertain if the attacks are preceded or associated with *dilatation of the pupils, sudden short periods of loss of consciousness*; or followed by short episodes of *automatism, brief amnesia, micturition and confusion*. Certainty as to the diagnosis of larval attacks can only be established by careful tracings from the electro-encephalograph, or watchful waiting to determine if more definite and characteristic signs of transitory loss of consciousness and movements occur. (Progression of Symptoms, Table 1.)

*Syncope* itself is differentiated from *petit mal* by the prodromal symptoms of pallor, sweating nausea and weakness. The cause for syncope is usually apparent; inquiry reveals emotional disturbances, anemia, cardiac irregularity, hemorrhage or hypotension. The patient recovers more slowly from a syncopal attack. On the other hand, the loss of consciousness in *petit mal* is sudden and transient, the momentary pallor is replaced by flushing and the fixed stare and dilatation of the pupils promptly disappears. Recovery is almost immediate and usually the patient has no idea or recollection of the event.

*Narcolepsy* (Gelineau, 1880) is the term applied to an *imperious desire for sudden sleep* occurring at various intervals and of short duration. The attacks may occur at any moment, even during activities such as eating, walking, or boarding a street car. The patient usually wakes suddenly with a clear mind. *Bradycardia* has been noted

by Kovacs but pupils are not known to be abnormal. Ephedrine and benzedrine sulfate are helpful in treatment.

*Cataplexy* is characterized by sudden attacks of loss of muscle tone. The patient falls to the knees or ground *without* loss of consciousness. Attacks are known to be brought on by extreme emotions of fear, anger, laughing or weeping. The pupillary response to light is retained, but the corneal and patellar reflexes are said to be lost. Fortunately the condition is rare, as it is most difficult to control. Notkin and Jelliffe believe the condition related to epilepsy.

*Pyknolepsy* ("frequent" seizures) refers to sudden flutter of the lids, turning of the eyes, arrest in the stream of thought, but without falling or convulsive movements—authorities agree that so-called pyknolepsy is in reality only an early arrested phase of *petit mal* and no differential diagnosis is necessary.

*Meniere's disease* may give rise to acute attacks of vertigo and falling to the ground with transient unconsciousness. It is easily differentiated from *petit mal* by the history, tinnitus, nausea, profound state of collapse and progressive deafness that ensues.

*Hysteria* and *simulation* are easily detected as the patient *closes the eyes* firmly during the attack, pupils react to light stimuli and *do not dilate*. Movements of the arms and legs are bizarre and irregular. Cyanosis is absent or poorly substituted by periods of straining. Muttering, crying, slurred speech and prolongation of the dramatic attitudes simplify the diagnosis. Injury, biting the tongue, and micturition rarely occur in the malingerer or hysterical individual. The reflexes remain unaltered and postconvulsive headache and dullness are lacking.

#### DIAGNOSIS

*Larval State.* In this group should be placed those patients who may suddenly alter behavior so that the abruptness, the purposelessness, and the repetitive type

of action strongly suggests something besides a "trend" toward a psychopathic state.

Where sudden periodic changes in behavior, personality, or activity arise out of an otherwise normal background, the present tendency is to consider such "temper tantrums," "behavior problems," or automatism as possibly related to the convulsive state—as based upon electroencephalographic evidence of dysrhythmia (Gibbs), but it must be recalled that similar findings are present in a wide variety of nonconvulsant types.

The "dreamy states" preceding or following well recognized minor or major convulsive episodes indicate, as Hughlings Jackson pointed out, that such manifestations may occur alone and in fact do, although the profession is more inclined to consider these in the realm of psychopathic disorders. The diagnostic boundary line in most instances is an artificial one and depends chiefly upon whether the symptoms are viewed by a psychiatrist or an organic neurologist. The use of the term "psychic epilepsy" or "psychic equivalent" seems to be the compromise of the moment.

Irritability, migrainous headache, outbursts of anger, personality changes, periodic jargon aphasia, amnesia and trance-like episodes are not necessarily confined to the early convulsive state. Many of these symptoms are common in organic lesions of the brain, as well as sequelae to severe head trauma, meningitis and encephalitis. They may follow a convulsive seizure, as well as precede it. Correction of some of these symptoms may be afforded by methods described below under *postparoxysmal state*.

*Minor seizures* (*petit mal*) are attacks characterized by sudden dilatation of the pupils, fluttering of the eyelids, deviation of the eyes, turning of the head, sucking or chewing movements of the mouth, swallowing movements, clucking and gurgling sounds with or without profuse salivation.

These minor seizures range from transitory moments of "mental lapse" or blurring of consciousness with an unnatural stare, to twitching and jerking movements beyond the patient's voluntary control.

Normal activities may be briefly arrested and then continue to original fulfillment of purpose without the victim being aware of interruption.

An arbitrary line may be drawn between a *minor* and *major* attack by the fact that the patient *does not fall*. Where sufficient loss of brain control permits the release of the "anti-gravity muscles," which maintain the postures of sitting or standing, it can be assumed that the attack is sufficiently profound to classify it in the major group, even though jerking movements are absent (cf. syncope and cataplexy).

*Jacksonian attacks* are focal fits characterized by sudden onset of localized sensory aura and, or, motor responses, with or without the subsequent loss of consciousness. Spreading of the sensory or motor phenomena in orderly progression from face, to arm, to leg, or vice versa, may be followed by a generalized major seizure. Twitchings or jerking movements may begin in the fingers, face, foot, et cetera before involving other parts. Usually some localized organic lesion of the brain is demonstrable by encephalography or operation.

Of most importance is the need for careful study in such cases to rule out cerebral neoplasm or other progressive organic lesion. In addition to the routine *neurological* examination, such a patient should have a *fundus* examination, *visual fields* charted, *x-ray* of the *head* with special films taken for *pineal* measurements (Chamberlain technic) in order to determine *displacement* of the gland if visualized. *Spinal puncture* with pressure reading, pneumo-encephalography (if no contraindication exists) along with routine blood, urine, and serological studies. The pneumo-encephalographic films will, in all probability, reveal the nature of the focal pathological process and

determine whether surgical relief may be indicated.

*Major seizures* (*grand mal*) may be ushered in by a sudden cry, gurgling sound, or, without warning, the patient may fall unconscious striking the head and injuring other parts of the body. Stiffening of the muscles begins almost immediately, usually with extreme turning of the head. An *extensor rigidity* often manifests itself and closely resembles the "decerebrate" attacks associated with lesions of the peduncles. This is known as the "tonic" phase. The breath is held, the patient becomes livid or cyanotic, the *pupils* are *dilated* and *fixed*, the cornea insensitive, the *eyelids* open, teeth and fists clenched, the body often in *opisthotonos*.

In ten to thirty seconds quiverings and small rhythmical jerkings of the flexor muscles of the upper and lower extremities arise (the *clonic* phase of the attack). Nystagmoid movements of the eyes and contractures of the face begin with increasing violence, so that the body appears to be almost torn apart, the head beats upon the floor, the breath is now forced in and out by the abdominal muscles. The tongue, forced out between the teeth, may be caught in the clamping movements of the jaws and badly lacerated. Increased salivation, bleeding, and turmoil within the mouth often produces *bloody foam*. Sweating, vomiting, incontinence and stertorous breathing ensue and the attack usually subsides after one to three minutes into a *post-paroxysmal* state with accompanying stupor (profound sleep).

It is important to note that although major seizures may occur without one or more of the above symptoms, there is no deviation from the pattern of flexor-extensor type of muscle response whether observed in the infant or the highly trained adult. These movements suggest an early motor pattern seen in the swimming action of ambloblastoma. *Never* do rotary, prehensile skilled movements, such as we see in chorea or athetosis, occur in a true convulsion. Differential diagnosis between

malinger, simulation and hysteria can be made upon this characteristic motor pattern alone. Dilated pupils, open eyelids and incontinence at the proper moment cannot be successfully imitated.

When *major convulsive seizures* are associated with *organic alterations* in the neurological findings—brain tumor, abscess, meningitis, trauma, edema, subarachnoid hemorrhage and local irritation to the brain surface must be considered and ruled out before the diagnosis of *grand mal* becomes valid.

*Postparoxysmal State.* The stupor and relaxation which follows a major seizure has been considered an "exhaustion phenomenon." Here again, closer analysis would indicate that appearances sometimes deceive use. When "status epilepticus" occurs, seizures may go on steadily for hours without signs of cortical exhaustion. Belief that the attack should be terminated in a few minutes because of inability of the motor mechanism to continue is far from the case in strychnine convulsions (spinal release), whereas those seizures produced by repeated "electric shock," profoundly exhaust the brain, and a period of recovery is required before another attack ensues. Subsequent convulsions can be induced repeatedly with appropriate stimuli in most instances of convulsive seizures, in which secondary changes in cerebral circulation and edema are not present.

The attack terminates in a state of profound sleep or stupor due to one of two fundamental reasons: (1) Sufficient circulation returns to the higher cortical levels to *re-establish* adequate metabolism and functions of *control* over the more primitive motor patterns, or (2) edema, pressure, and anoxia build up in the brain tissues to such a degree that circulation to the cortex is insufficient to maintain further metabolic function to the motor elements involved and movements cease with signs of temporary flaccid paralysis as in a "stroke." It may be true that the motor cells "exhaust" their available supplies of

oxygen and energy, but from a prognostic standpoint, the important feature to bear in mind is that *all* of the cortex and *other* ganglion cells devoted to *memory, hearing, integration* and *higher intellectual functions* are sharing in this generalized widespread edema, pressure and anoxia, so that instead of the concept of simply motor elements alone becoming exhausted, such as seen after violent exercise, the brain as a whole suffers severe damage, and *progressive mental deterioration* develops relentlessly with recurrent seizures.

The postparoxysmal state must, therefore, be carefully observed by trained personnel or someone in the family delegated to record duration and events. It is the period of stupor and anoxia that is disastrous to the brain, not the fit. If this phase can be shortened or terminated by general measures of dehydration, the patient's prognosis from the standpoint of mental integrity is greatly enhanced.

It will be found that at one extreme of this postparoxysmal phase we have *somnambulistic* behaviors, in which walking, running, dressing and undressing, fighting, automatism and repetitive movements and acts indicate an altered coordination of consciousness, but still sufficient retention of cerebral circulation and metabolism to carry on most of the fundamental processes of *upright posture*, balance, speech, movement and even good judgment such as demonstrated in avoiding obstacles and solving problems involving passageways, stairs, shoe laces, buttons, et cetera.

On the other hand, patients manifesting incontinence of bowels or bladder, wide pupils, divergences of the eyes, loss of deep tendon reflexes, positive Babinski sign, or stertorous breathing and pulse pressure above 50 mm. of mercury are not unlike individuals suffering from the severe effects of *concussion* due to head trauma. Such patients should be treated for *cerebral edema* along the lines established for head trauma (immediate and complete spinal drainage, strict fluid limitation, appropriate tissue dehydration (purgation and

sweating), regulation of salt, sweets and diet) if progressive mental impairment is to be avoided.



FIG. 1. Pneumo-encephalogram in the sitting position showing air in the subdural space, which has replaced an abnormal collection of cerebrospinal fluid. Note displacement of the brain away from the sinus and the consequent stretching and narrowing of the attached cortical veins. Fluid level can be seen gravitating toward the base. In this instance, air introduced by the spinal route has found access to the subdural space through some tear in the arachnoid. This type of subdural hygroma is, therefore, drainable by spinal puncture. Other supracortical collections must be drained directly through trephine opening of the skull.

As appropriate treatment depends upon proper diagnosis, it is obvious that sedation and temporary supervisory restraint (often increase in sweets and forced feedings) are needed to "slow down" the "psychic equivalent" type, whereas diametrically opposed therapy of *activity, elimination*, and restrictions of food and fluid are required for the "stupid" stuporous type.

There are patients that manifest prolonged periods of postparoxysmal *hallucinations, amnesia, excitement, incoherence* and *violent impulsive acts*. These manifestations are not unlike those encountered in *delirium tremens* and are probably due to

the same cause; namely, abnormal collections of clear subdural fluid (hygroma). If bilateral trephine is done in the temporo-occipital area with the patient in the sitting position (fluid gravitates to the base), large quantities of fluid can be drained off from over the arachnoid and cortex.

Spinal (subarachnoid) fluid escapes into the subdural space from a "leak" in the arachnoid, probably forced out during the violent stage of the seizure. This fluid is not drainable by spinal or cisternal puncture as it lies in the *subdural* space. It tends to gravitate to the temporo-occipital areas (visual-auditory zones) as the patient usually lies on the back (restrained) but the fluid may be moved to the frontal poles if the patient is placed face downward.

Ounce for ounce, the disturbance in blood volume relationships by this abnormal collection of fluid within the skull is the same as that of a clot, tumor or abscess. The only difference is that spinal fluid is clear and mobile giving rise to fairly generalized symptoms of disturbance, whereas a clot is blue-red and circumscribed, giving rise to focal signs in advance of the generalized circulatory impairment.

At necropsy the subdural clot is easily demonstrated, whereas the fluid trickles away while the skull and dura are being removed, leaving the pathologist nothing "significant" to report and the mystery unsolved. Since operating on such types in the sitting position (fluid gravitates to the base), draining the subdural space for thirty-six hours, the symptoms of hallucinations, excitement, amnesia, and mental torpor promptly disappear and are correctable in most instances as long as the subdural fluid collections can be prevented from recurrence (curtailment of liquid intake, solid or dry diet).

With encephalographic demonstration of the presence of abnormal collections of subdural fluid in a large number of these types, the diagnosis has been confirmed by neurosurgical verification, and sympto-

matic improvement follows appropriate methods of drainage. (Fig. 1.)

Thus a large number of postparoxysmal manifestations fall chiefly into three types of altered cerebral circulation: (a) Prompt and almost adequate return of circulation (metabolism). The patient may recover consciousness promptly with clear mentality or only transitory confusion; (b) impaired cortical capillary network circulation (subdural fluid, "wet brain") and venous stasis (narrowing of veins due to displacement of the hemisphere away from the attachment of the veins entering the dural sinuses). The patient may manifest prolonged abnormal sensory or motor manifestations before or after attacks (c) Intrinsic swelling and edema of brain tissue due to profound anoxia and pressure. The patient appears to be severely "knocked out" by the seizure but recovers gradually. Headache, vomiting, dullness and mental deterioration are commonly associated with this group.

Various degrees and combinations of the above altered physiological relationships have been observed at operation in psychotic states with or without convulsions. The "psychic equivalent" group no longer rests upon "unknown pathology" but requires a diagnostic pneumo-encephalogram and volume displacement measurements to establish the diagnosis, as well as correct the underlying circulatory disturbance.

#### CIRCULATORY CONSIDERATIONS PREDISPOSING TO SEIZURES

Sharp exsanguination, sudden clamping of the jugular veins, or compression of the arteries in the neck may produce convulsive seizures (Kusmaul and Tenner\*). Failure of the ventricle of the heart to beat for three to seven seconds (pulse 8 to 20 per minute) may produce unconsciousness, and *asystole* lasting for fifteen to twenty

seconds is frequently associated with convulsive seizures (Sir Thomas Lewis\*).

Thus careful examination and observation must be carried out to detect *cardiac syncope* as well as cerebral circulatory insufficiencies that may be intermittent or chronic. The following considerations must enter into every obscure problem of convulsive seizures presented for diagnosis:

#### *Cardiocirculatory Insufficiencies:*†

##### I. *Cardiac Syncope:* (Intrinsic disturbance of output of the heart in spite of adequate venous return)

##### (a) *Stokes-Adams Syndrome* (arteriosclerotic background)

##### (1) Severe paroxysmal bradycardia

##### (2) Ventricular standstill

##### (3) Vagal attack plus ventricular fibrillation

Carotid sinus reflex

Habitual slow pulse

Extrasystoles

##### (b) *Partial heart block:* Severe lapse of ventricular beat (intermittent and recurrent asystoles produce fits at variable intervals; prolonged episodes associated with a combination of (a) and (c) may produce "Status Epilepticus"). The convulsions usually occur without warning (aura), incontinence and tongue biting are rare, bradycardia is present at the time of the attack and the transmitted auricular contractions may even be visible in the veins of the neck.

##### (c) *Tachycardia or Ventricular Fibrillation:* When the rate reaches 200 or more per minute, little or no blood is forced into the arteries, blood pressure falls and cerebral circulation fails. *Spasm* or occlu-

\* Lewis, Sir Thomas. *Osler's Modern Medicine*. McCrae IV, 3d ed. 402. Philadelphia, 1927. Lea & Febiger.

† Roesler, Hugo. The author is indebted to Dr. Roesler for suggestions and assistance in the arrangement of the cardiocirculatory insufficiencies.

\* Kusmaul and Tenner. *The Nature and Origin of Epileptiform Convulsions Caused by Profuse Bleeding*. Trans. E. Bonner. London, 1859. New Sydenham Soc.

sion of the coronary artery, wounds of the heart, poisons, electrical shocks and large doses of suprarenal extract may precipitate fibrillation.

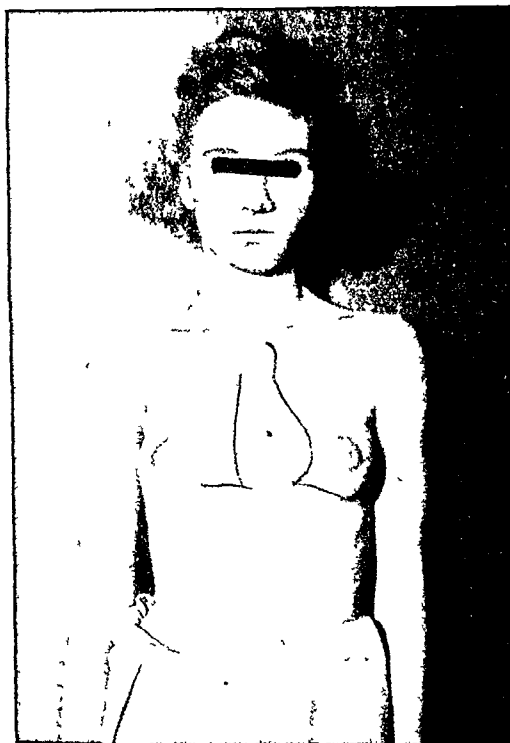


FIG. 2. Structural inadequacy showing long neck, small chest and heart; ten-year old pattern, with development of extremities and adult relationships elsewhere. (A. O., age fourteen.)

(d) *Aortic Stenosis:*

- (1) Congenital
- (2) Acquired—trauma, aneurysm, sclerosis

II. *Relative Cardiac Syncope:* (Inadequate capacity of heart in spite of normal mechanism)

- (a) Small infantile hearts (as shown by orthodiagrams). Small underdeveloped carotid arteries
- (b) Disproportionately long neck, increase in distance between the aortic valve and vertex of the skull, demanding greater than normal cardiac effort or capacity.

*Circulatory stasis* and insufficiency arises at the brain level if blood pressure falls even moderately in this group. (Fig. 2.) It is obvious that a small heart, failing to deliver blood to the brain because of a greater height and distance to overcome than in the normal, presents the same potential type of circulatory stasis as far as the brain organ is concerned as the mechanism of asystole would to an otherwise normal heart and vascular set-up (cf. Stokes-Adams syndrome).

- (c) Stenosis of carotid canals in the skull, compression of both the carotid and vertebral arteries by tumors, cellulitis or swelling. Vascular anomalies, aneurysms and abnormal patterns which profoundly impair total cerebral circulation.
- (d) Relative structural inadequacies of chest and heart due to rapid growth of head and extremities in puberty or adolescence. (Six to seven year old chest and heart size with arms, legs, neck and head of fourteen to sixteen year-old pattern)

III. *Vascular Syncope:* (Insufficient return of venous blood for required output and pressure)

- (a) *Exsanguination and profound anemia*
- (b) *Splanchnic dilatation and shock*
- (c) Compression or obstruction to the *vena cava*
- (d) Adrenal insufficiency
  - (1) Acute hemorrhage
  - (2) Chronic (Addison's) disease

IV. *Jugular Occlusion:* (Impairment of cerebral venous drainage, stasis and edema at the brain level)

- (a) *Acute thymic swelling* with compression of both jugulars passing through the bony thoracic ring

- (b) *Swellings* in the neck (metastatic tumor, paratonsillar abscess, cellulitis)
- (c) *Traumatic or infectious thrombosis* (where stenosis of the jugular foramen or underdevelopment of one jugular outlet (as shown by x-ray) exists, occlusion of the "dominant" sinus\* or vein may result in cerebral edema and "Status Epilepticus.")

#### INTRACRANIAL FLUID CONSIDERATIONS PREDISPOSING TO SEIZURES

A. "Toxic" Types: (Water intoxication). Convulsions that arise during an acute illness; or for some so-called "toxic" cause, will be found in most instances to be associated with a profound disturbance of water metabolism and coincident "wet" brain. When renal elimination becomes impaired, or the escape of moisture from the skin surface is curtailed (as in fever or cold weather), a state of water retention arises similar to that induced experimentally by Fremont-Smith, McQuarrie and others. They have demonstrated that convulsions in animals and human beings may easily be induced by forcing fluids (mouth, vein, or subcutaneously) after temporarily shutting the kidneys down with injections of posterior lobe pituitary extract. This is essentially the same mechanism as that spontaneously encountered in eclampsia, in which pituitary dysfunction, hypertension and retention of fluid associated with faulty renal and skin elimination give rise to convulsive attacks (Fay, Arnold,† Behney). If other vasospastic or arteriosclerotic processes are deemed responsible for the renal failure, the term "uremic,"‡

\* In 85 per cent the right lateral sinus and jugular are larger than the left. In approximately 5 per cent one jugular is so large and "dominant" that if occluded, circulation cannot be taken over sufficiently by the smaller remaining vessel and delay and stasis in the brain tissues may result.

† Arnold, J. and Fay, Temple. Eclampsia; its prevention and control by means of fluid limitation and dehydration. *Surg., Gynec. & Obst.*, 55: 129-150, 1932.

‡ I have observed patients with high blood urea (in one instance 110 mg. per 100 cc.) without loss of con-

sciousness or convulsive seizures. or "toxic" or "essential" is usually applied to the convulsions.

It is now believed that the convulsion is not produced by "poisons" or vague "toxins" but rather by a disturbance of electrical cellular potentials, oxygen, permeability and conduction. The rising tide of intracranial fluid permits displacement of circulatory blood volume and consequently metabolic alterations, failure of controlling areas through circulatory stasis and finally, release of primitive motor patterns as the externalized manifestation of a seizure.

B. *Hydration Types*: (Fat, water-logged, hypogonadal types). A state of *water intoxication* (Rowntree) may be easily induced in certain persons and animals by the simple process of *overindulgence in fluids* when the portals of elimination are inadequate. Typical convulsive seizures arise and may even progress to a fatal form of "status epilepticus" unless satisfactory drainage of fluid from the subarachnoid spaces (spinal puncture), the subdural space (trephine), and the interstitial brain spaces (dehydration) can be promptly accomplished.

In this type we find the "wet brain" of *trauma* as well as the *alcoholic* "wet brain" (in which mild trauma precipitates edema of brain tissue on top of overfilled subarachnoid channels; or ruptures of the arachnoid permitting the formation of a subdural hygroma). "Wet brain" may also be associated with severe venous stasis, due to occlusion or inflammation of the dural sinuses (superior and lateral, or cavernous), *constriction of the jugular veins* in the neck or chest, by *thymic enlargement*, or *thrombosis* from mastoid disease.

Certain *drugs*, *allergies* and *anesthetics* may produce a rapid increase in intra-

consciousness or convulsive seizures and, on the other hand, have seen convulsions most frequently when the blood urea was only slightly elevated, if at all. In either instance, in which convulsions exist, trephine or encephalogram has revealed increase in the volume of subarachnoid; or subdural fluid (wet brain), with or without increase in spinal pressure. The operative findings are identical with those of "water intoxication."



cranial fluid due to transudation into the tissue spaces.

It is striking with what rapidity *ether* brings about increase in subarachnoid (spinal) fluid and actual swelling of the brain.\*

Although some vague "toxic" agent is usually said to be the cause of the convulsive seizures, one of the outstanding common denominators so far evident in widely separated clinical states, concerns intracranial changes in intracranial fluid volume and cell permeability (altered cell surface potentials and electrolytes—Spiegel and Spiegel-Adolf) similar to those noted in *water intoxication* itself.

It is evident that the water *per se* is not responsible for the seizure. The attack arises from *altered physiology of tissue, conduction* and "*threshold of control*," which are all affected by lack of oxygen, altered sugar and carbon dioxide metabolism and finally to inadequate intracranial blood volume and circulation due to displacement by the rising tide of fluid.

As the walls of the craniovertebral cavity cannot expand, an increase in fluid volume in the tissues of the brain or subarachnoid spaces can only mean an equal displacement of some other volume (Monro-Kellie). At the moment, at least, this chiefly concerns blood volume.

As the fluid volume rises within the skull (obvious in the open fontanel or area of decompression of the skull), circulatory blood volume is diminished so that the loss of higher controlling centers may allow the patient even to become unconscious.

It is known that drugs or physical agents which tend to increase cellular permeabil-

ity to fluid *favor convulsive seizures* in the predisposed case, whereas drugs which tend to prevent easy permeability of fluid into the cells *prevent attacks* (Spiegel, measurements of the delta). When the inhibitory and restraining influences of the higher cortical levels are diminished, normal or abnormal stimuli may reach and discharge the motor patterns otherwise held in constant control.

An experience familiar to all will serve to illustrate a familiar normal mechanism: If a gun is fired close behind a person unaware of such a possibility, a sudden generalized "defense response," such as jumping, screaming, et cetera, usually ensues. If, however, the individual is shown the gun and has time to set and "control" the motor mechanism, no overt response occurs. Thus the same stimulus that reached the brain at an unguarded moment and produced a startled spasm, is harmless in its effect when anticipated and properly controlled. If repeated "jumping" movements were to occur suddenly without a detectable noise or cause, the individual manifesting such actions would undoubtedly be suspected of having "epileptoid" tendencies. The electro-encephalogram has shown bursts of abnormal waves may surge through the brain without external stimuli and the motor discharges which follow are thought to be due to these spontaneous waves.

#### CONVULSIONS IN INFANTS AND CHILDREN

Almost two-thirds of all convulsions occur within the first two years of life. Comparatively few seizures arise between the years of three to seven. After this time, disproportionate growth (inadequacy of circulatory function) and puberty predispose the child to convulsions. Only about 23 per cent of attacks arise after the completion of the growth period (eighteen to twenty years female, nineteen to twenty-two years male) and these are usually easily identified with demonstrable organic lesions (so-called *symptomatic epilepsy*).

\* With the human cortex exposed, (the patient under avertin, local anesthesia, quiet and relaxed on the operating table) we have often observed swelling of the brain begin within thirty seconds after a few whiffs of ether had been inhaled. As this increase in tissue fluid volume occurs in the absence of straining or holding of the breath, and will continue if not checked to actual protrusion of the brain above the scalp level, it indicates the degree of danger from intracranial pressure that exists when *ether* is given to patients in whom an hydration state already exists, also the rapidity of fluid accumulation possible under certain circumstances.

Diagnosis is usually most difficult in the infant group because of the many limitations for adequate study due to size, age and lack of co-operation.

The so-called "cause" for infantile convulsions can usually be found associated with one or more of the following significant *predisposing factors*:

### I. Birth Trauma:

(a) *Asphyxia of brain tissue* (lack of oxygen for ninety seconds or longer)

1. Delay in breathing after delivery
2. Imperfect circulation, cardiac anomaly or defect (blue baby)
3. Obstruction of jugular return from brain

(x) Delay in rotation of after coming part (compression or twisting of neck)

(y) Strangulation by cord or forceps

(z) Structural anomalies, thymic enlargement

(b) *Subarachnoid hemorrhage* (bloody spinal fluid)

1. Increase of pressure due to retention of spinal fluid

(x) Hydration

2. Communicating hydrocephalus

(x) Generalized at vertex or base, mental retardation, delay in walking and talking

(y) Focal

Unilateral (hemiplegia—flaccid or spastic)

Bilateral (spastic diplegia—Little's disease)

3. Porencephaly

(x) Intracerebral hemorrhage or thrombosis with liquefaction of cerebral tissues and eventual rupture into the ventricle or to the surface (up to third month of life), occasional

cortical cyst and scar formation

### (c) *Subdural collections*

A. *Hemorrhage* (clear spinal fluid)

- (1) Rupture of tentorial veins, clot at the base (vomiting and generalized symptoms; stiff neck and stupor)

- (2) Rupture of cortical veins, clot over hemisphere (irritability, dilated pupil on side of clot, focal signs with paralysis, and stupor)

- (3) Rupture of arachnoid, combination of blood and fluid covering one or both hemispheres

B. *Hygroma*—"wet brain"

- (1) Spinal fluid escape into the subdural space. (Myotic pupils, dullness, prolonged attacks with tendency to "status epilepticus" followed by generalized flaccidity and stupor). Such collections of fluid are not drainable from the spinal canal (unless wide rupture of the arachnoid at the base is present). Direct approach through the skull is required to save the patient's life.

### II. *Cerebral Venous Stasis*:

- (a) Enlarged thymus (jugular compression at the first thoracic ring)

(x) Status lymphaticus (often fatal)

(y) Laryngismus stridulus (diphtheritic)

- (b) Swellings of the neck

(x) Infections

(y) Edema

(z) Hematoma

(c) Congenital absence or stenosis of the jugular foramina of the skull.

(x) Nocturnal attacks when sleeping on abdomen with neck sharply turned

### III. Circulatory Inadequacy (Cyanosis, murmurs, enlarged heart):

(a) Patulous foramen ovale

(b) Aortic stenosis

Clinical findings, alteration in heart size, murmurs, etc., make diagnosis possible

### IV. Acute Brain Infections:

(A) *Direct Involvement* (Inflammation, edema, intrinsic irritative and destructive lesions, local and generalized seizures; outcome depends upon the disease)

(a) *Encephalitis* (fever, headache, dullness or irritability, twitching of muscles, double vision, loss of convergence, oily skin, atonic facies)

(b) *Meningitis* (fever, stiffness of the neck, headache, vomiting, increased spinal pressure; choked disc, convulsions are usually generalized)

(1) Suppurative

(2) Tuberculous

(3) Cerebrospinal epidemic

(4) Virus—hydrophobic tetanus

(B) *Indirect Involvement* (Paradural reaction, effusion, wet brain, edema, water intoxication type)

(c) *Mastoiditis and Sinusitis:*

Usual history of running ear or upper respiratory infection, swelling of anterior and posterior cervical glands, fever, headache, vomiting, slow pulse, marked tender-

ness over carotid arteries in the neck, convulsions are Jacksonian or generalized, trephine discloses marked "subdural wet brain"

(d) *Whooping Cough:* Venous back pressure produced by prolonged spasms of coughing as well as cyanosis and asphyxia. Subarachnoid hemorrhage may arise due to excessive straining precipitating focal seizures, "status" or paralysis

(e) *Scarlet fever, diphtheria, measles and other acute toxic states:* Convulsions may be serious and even fatal unless the acute "wet brain" characteristics underlying the attacks are recognized. Toxic renal shut-down with no skin elimination (dry, feverish) favors water intoxication and "wet brain" especially if fluids are forced in this period. (Treatment: purgation, sweating, fluid restriction, *spinal drainage* or subdural drainage)

### V. Chronic Brain Infections: (Subarachnoid fibrosis, communicating hydrocephalus, and wet brain type)

(A) Congenital syphilis—(Wassermann may be negative); structural and intrinsic lesions, scars and atrophy, stigmas of degeneration

(B) Tuberculosis—arachnoidal scars, isolated tubercles and zones of inflammation (granulomas)

(C) Postmeningitic adhesive arachnoiditis

Symptoms and diagnosis similar to post-traumatic group. Diagnosis established by encephalogram along with history, clinical and laboratory findings.

VI. *Metabolic Disturbances:**Calcium Deficiency* (Blood Calcium below 8)

- (a) Parathyroid insufficiency
- (b) Rickets
- (c) Spasmophilia
- (d) Tetany

*Sugar:*

- (a) Hyperinsulinism (excessive therapy)
- (b) Adenoma of the pancreas

*Carbon Dioxide:*

- (a) Hyperventilation (blowing off of carbon dioxide)
- (b) Alkalosis (lack of acid or carbonic acid).
- (x) Excessive sodium bicarbonate, etc.

*Water:*

- (a) Hydration states
- (b) Hypotonic solutions (intravenously)

VII. *Drugs, Poisons* (From mother or environment):

- (a) Lead encephalopathy (eating paint off cribs, occupational, accidental)
- (b) Strychnine
- (c) Camphor, picrotoxin, metrazol, alcohol, thujone, absinthe
- (d) Electricity
- (e) Insulin, pitressin

Many of the above considerations apply equally well to the adolescent or adult. It must be emphasized that the higher incidence of attacks in infants and children is probably due to the immature state of development of the *controlling centers* in the brain. Sensory stimuli are more intense (unmodified or dampened) and there is less control over the "defense" and subcortical reflex motor patterns.

Thus some of the older concepts may be understood if given one or more of the above predisposing factors, the aggravation caused by "teething," worms, phimosi, irritating foods, etc., could easily upset the unstable cerebral controls of early life. During this period, sudden loud noises may produce violent responses that would be

entirely controlled in later life. It is well known that in strychnine poisoning the sound caused by the slam of a door, or clap of the hands may be enough to precipitate a convulsive seizure. Thus a common impulse (sound, light, pain, vibration, touch) may be all the stimulus necessary to "touch off" an attack if the control mechanism is withdrawn. "Thresholds" for control of motor patterns are far from developed at birth. In the legs these are not complete until walking is established.

## COMMON DENOMINATORS CONCERNED WITH CONVULSIVE SEIZURES

Summarizing some of the inter-relationships of oxygen, water, and carbon dioxide in the predisposing of an individual or animal to an attack, the chart on page 328 (modified from Lennox and Cobb) is most illuminating.

Anoxia favors increased permeability of the capillaries to fluid, giving rise to rapid transudation of fluid into the tissues with consequent swelling. This increased fluid volume pushes out still more blood from the cranial cavity causing more anemia of the brain and a vicious cycle with mounting anoxia and further edema.

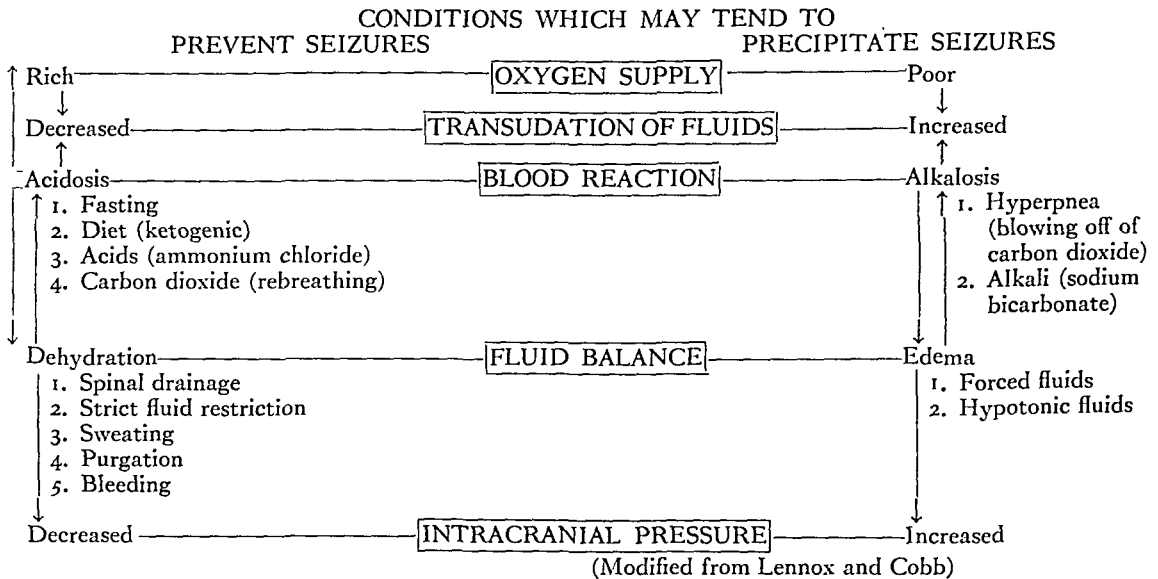
Now that everyone can enjoy a convulsion when we choose to produce it, the obvious fact that a perfectly normal and adequate brain may suffer profoundly from purely extracranial causes (viz., "poor plumbing" system for blood delivery and drainage) or inadequate nutrition and circulation, might well justify the organ in "having a fit" over the fact that its existence and survival is constantly jeopardized.

We have studied and observed more than 1,200 problems of the convulsive state in all of its clinical neurological and neurosurgical aspects during the past sixteen years. Aside from the organic cases, 820 so-called epileptics were treated along the lines suggested by the diagnostic disclosures indicated above. Our emphasis has been on correction if possible of the physiological, structural, chemical or metabolic disturbance. Three out of four of

these patients have found satisfactory improvement and control.

The objective has been to apply to the brain organ as a whole the first principle of medicine or surgery, "An organ functions and heals best when it has a normal and adequate blood supply."

Medication should be restricted to a minimum (phenobarbital  $\frac{1}{4}$  to  $\frac{1}{2}$  gr. two or three times daily). We believe that larger doses "slow down" the patient as well as obliterate the seizures. It has seemed to us it is more important to observe the favorable recession of seizures



Where small hearts existed, the patients have been put on the rowing machine, the track, routine heavy exercise. Deep breathing and "pull-ups" have helped to develop the chest.\* Where hydration states exist (overweight, "one pint equals one pound"), appropriate curtailment of liquids and correction of diet has helped to prevent chronic "high tides" of fluid in the brain cavity. Toxic states with "water intoxication" patterns require temporary curtailment of liquids by mouth, vein or bowel, or drainage of spinal fluid as well as improvement in the ultimate portals of elimination (skin and bowels).

\* The author is indebted to the Y. M. C. A. for their intelligent assistance in the correction of many relative inadequacies of the growth period. One must expect a short interval of increase in number and severity of attacks if sudden transition from a state of quiet sedation to one of strenuous exercise is attempted. Attacks due to "hyperventilation" can be overcome by teaching deep breathing and by increasing the size of the chest in order to establish an adequate carbon dioxide reserve, so that the ordinary demands of excitement and activity can be met without danger of a seizure.

in the order of improvement and control (Table 1) than it is to expect the drug to "cure" the condition by removing the seizure from before our eyes. As the convulsion is a *symptom complex*, drugs are only of temporary value and cannot be considered "curative" as quinine is for malaria.

As in other clinical problems (diabetes, syphilis, etc.), signs and symptoms may improve before they disappear. Those that consider any and all attacks of equal importance and fail to press the direction of treatment as improvement indicates will find that the use of drugs only permits the conditions underlying the attack to become worse, so that more sedation eventually is required and a false sense of security permitted to arise.

Too many members of the profession today indulge in the practice of "wishful thinking" in hopes that the condition will eventually correct itself or that the patient will "outgrow" or "outlast" the "disease." Such spontaneous physical adjustments

are known to occur and should increase our desire to hasten their fulfillment.

In considering *diagnosis in convulsions*, what formerly was a simple matter of differential diagnosis, and an individual matter as to expediency in selecting a name ("epileptic" or "epileptoid," if the supposed cause was easy to find; if obscure, "cryptogenic," if unknown "idiopathic") has now required the most important far-reaching and exhaustive analysis and attack upon the problem.

Success or failure in treatment of the patient may depend upon full and proper diagnosis. The former "causes" now become "predisposing factors." No longer do we speak of brain tumor or cortical scars as the "cause" of the seizure. It is true that their presence has altered local physiology, but removal of the tumor or the scar *does not always bring relief from the attacks*. Convulsions occur most frequently without the assistance of tumors or scars. The old "Post hoc propter hoc" weakness in medical reasoning still deludes those who allow their visual impressions to stop their continued contemplation of the problem.

It is, of course, evident that the scar or tumor is present every minute of the day and night and yet the attacks may be far apart or only once a week. If the lesion itself were the cause of the attacks, its *constant* stimulus should produce *constant* and continuous convulsions. To explain away this fact the idea of a "Lyden jar or battery" has been advanced by those who claim that energy is stored up until the discharge level is reached. "After discharge it takes time to again charge the battery." Anyone who has watched a case of "status epilepticus" has hoped and prayed that the "battery" would rapidly become discharged and the convulsions cease. Unfortunately, the explanation is not sufficient, for it is as unreasonable to expect to exhaust a convulsive mechanism (unless circulation to the motor areas is impaired) as it would be to expect a runner or swimmer to stop after a few minutes

and wait days in order to proceed with muscular activities again.

In all of the organic processes we know associated with convulsive seizures, there has always been the additional unknown "X," the strange factor that came and went without a trace. As we find more and more "normal" elements in convulsive manifestations (which we have too long considered pathologic), we shall begin to speak of "normal" convulsive seizures when viewed dispassionately and compare these "standard types" with those of "atypical" character.

The prejudice with which the profession has viewed the mechanism of a convulsion as an "evil" and *undesirable affliction* of man is both unreasonable and unsound. The mechanism of labor is an unpleasant thing to watch and yet science has established its normal and abnormal characteristics. The possibility of this mechanism is inherent in every female but latent until called into active need. The same may be said of the convulsion, as it is inherent in both human and animal life and perhaps at one time in the long evolutionary process it, too, may have served a useful purpose.

At the fish level, head, eyes, tail and paddle movements join in convulsive efforts ("like a fish out of water") to regain the protection of the seawater with its abundance of electrolytes and oxygen—at the human level, to regain for the brain organ this same intrinsic need.

The "work-out" that a major convulsion gives to a patient with the coincident sweating, micturition and defecation rivals some of the best health resorts and elimination fads of the day. If it were not for the unconsciousness and "purposeless" movements (Piscian-Amphibian movements), one might compare the effort and violence at times with the running of the Olympian 100 yard dash.

Convinced that the profound mechanism of a seizure has not been developed or retained in the nervous mechanism throughout the evolutionary ages without some beneficial reason or purpose (cf.

the "evil" vermiform appendix as a vestigial organ, or the complicated actions seen in the vomiting mechanisms and those of shivering, fever and others, which have all eventually been explained and accepted as "normal" although at one time regarded as pernicious), it seems reasonable, in certain inadequate types, that we might anticipate nature's need for better development and function by *forcing exercises* in order to build a better circulation (athletic "Work-outs" instead of medicinal "black-outs"). Either because of, or in spite of, this new approach to the problem, we are now controlling 16 per cent more of the former "hopeless hereditary types" of the convulsive state than we did ten years ago and certainly what we have done, others can also accomplish, provided they approach the problem with an open mind and a diagnostic determination.

The same sound clinical view should prevail in dealing with the convulsive state as that which is maintained in diabetes; namely, that occasional reappearance of sugar in the urine or a momentary return of high blood sugar is not necessarily evidence of failure of the method of treatment, rather it is an indication to pursue with more care and detail the program responsible for bringing the more serious aspects and symptoms under definite control.

Those patients or physicians who merely count the *number* of attacks, as a basis of measuring the value and possibilities of treatment, often become discouraged during the most important and critical phase of improvement, when many minor attacks may take the place of a single major seizure (ratio about 3 to 1).

Minor seizures have not, in our experience, been associated with mental deterioration, whereas, the major seizure, with its subsequent period of stupor, has frequently been associated with bodily injury and serious regression of mental processes.

In our experience\* the severity of the

case is not to be measured by the number of attacks or the violence of the muscular response, but rather by the length of the period of stupor and sleep, following a seizure. As the patient improves, this period of unconsciousness shortens until finally attacks without loss of consciousness may occur or minor seizures without falling intervene. Conversely, if the attacks are associated with increasing periods of stupor and sleep, the patient's condition may be considered as progressing unfavorably.

Careful observations regarding the duration of the true period of unconsciousness should be recorded and compared from time to time, in order to evaluate the efficacy of treatment properly. It is, therefore, desirable to observe from time to time periods free from the use of drugs to determine what progress may have been made by corrective physical measures.

#### DISCUSSION

We have become convinced for many reasons that a convulsive seizure is closely associated with a selective degree of stasis or failure in cerebral circulation.

For the purpose of analysis and treatment, we have considered the seizure as a "protest" on the part of the nervous mechanism against circulatory failure as a serious threat to its integrity. Thus, after correction of inadequacies and improving circulation and routine, a large group of individuals, formerly considered as suffering from "essential," "idiopathic," "cryptogenic" or with other obscure so-called "hereditary" backgrounds, have in reality revealed themselves to be transient problems of physiohydrodynamics based upon structural inadequacies and ineffective levels of circulatory volumes within the cranial cavity.

We continue to emphasize that if a full diagnosis is to be made and therapeutic agents intelligently planned, a relentless

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symptoms of convulsive attacks hospitalized for diagnostic study, and based on 1,640 encephalographic and volume replacement measurements in the organic and convulsive groups.

\* From personal observations on 823 patients with

search must be undertaken for those factors which might impair cerebral circulation and thus "*predispose* the individual toward a convulsive seizure."

Twenty-two per cent of 2,000 patients studied by Lennox had important contributory causes as follows (symptomatic epilepsy):

	Per Cent
Congenital brain defect or birth trauma.....	5.6
Brain injury after birth.....	5.7
Infection of the brain.....	4.2
Tumors of the brain.....	2.6
Defect in brain circulation.....	1.9
Miscellaneous brain lesions.....	1.5
Conditions outside the brain.....	0.9
	22.4

Our clinical studies have revealed that 84 per cent of patients revealed important contributory causes if the additional factors surrounding disturbed water balance, circulatory and structural inadequacy, volume displacement and pneumoencephalographic alterations from the normal are also taken into consideration.

The clinician must include in his survey of "conditions outside the brain" the circulation from the heart, through the structures and vessels of the neck into the skull; within and around the brain, back along the venous pathways to the chest and heart again.

We have only to call attention to the Stokes-Adams syndrome or severe bradycardia; to the carotid-sinus-symptom-complex of altered arterial pressure and flow; to compression of the jugular veins by an enlarged thymus at the level of the bony ring of the first rib; to postpharyngeal abscesses, swellings and occlusions in the neck; to congenital absence and anomalies of the jugular foramina of the skull, as well as to the many direct and indirect causes for alteration of circulation within the cranial cavity, itself, to indicate many easily detectable extraneous "causes."

We have found in the pre-adolescent and adolescent group a tendency for the head, neck and extremities to grow rapidly, but

the chest to be retarded (Fig. 2), so that the heart is small, the vessels of the neck and holes of entry into the skull infantile,

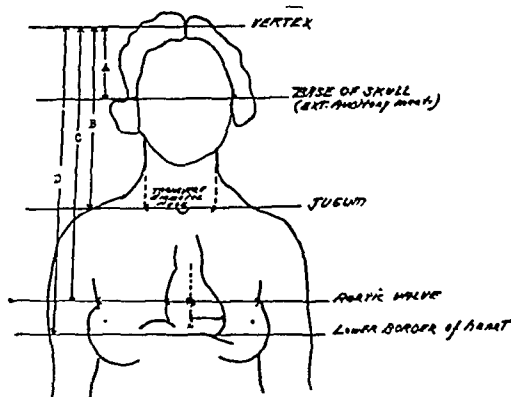


FIG. 3. Orthodiographic measurements as taken by fluoroscopy. A, vertex to base of skull (external auditory meatus); B, vertex to jugular notch; C, vertex to aortic valve; D, vertex to lowermost border of heart; E, transverse diameter of heart.

and yet the demand for blood by the large growing brain organ is very great.

When a certain degree of disproportion is reached between the "pump" (heart, as a source of blood supply) and the brain, then trivial states of hydration, excitement, or overfatigue act as *precipitating* factors and may lead to a convulsive seizure which otherwise would not arise in a normally balanced individual.

Figures 4 and 5 illustrate the striking structural inadequacies which are to be found in a group of so-called idiopathic, institutionalized epileptics as compared with a similar age group of "normal" boys attending Y. M. C. A. gymnasium classes.

Alterations of blood flow to the brain, either by clamping both jugulars, simultaneously (Kussmaul-Tenner attacks) or by arresting the movement of circulation for from nine to seventeen seconds (Stokes-Adams syndrome) will frequently be sufficient to precipitate a convulsive seizure.

This fact is extremely important in the analysis of nocturnal attacks. Seizures at night are often unrecognized until the individual may find blood stained bedding or complain of a "sore" tongue or "sore" muscles, or some individual observe a true seizure.



Children frequently sleep on the abdomen and we have found several instances in which turning the head sharply to one

convulsions have been entirely controlled by forcing the individual to sleep on the back or preventing acute flexion of the



FIG. 4. Normal boys, six to ten years of age (Y. M. C. A. class). Compare chest, neck, head and extremity proportions with similar age group of structurally inadequate epileptics in Figure 5.



FIG. 5. Chronic, institutionalized, epileptic boys, six to ten years of age. Note marked disproportion between chest, neck, head and extremity development, high incidence of structural inadequacies and abnormalities. (Courtesy of Dr. A. W. Pigott, Skillman Colony.)

side (in the presence of demonstrable anomalies of the venous outlets to the skull) compresses the "dominant" jugular vein, causing a rise in intracranial pressure and impairment of cerebral circulation as demonstrable by the "Tobey-Queckenstedt" test. In at least eight instances the

head and neck. This has been accomplished by devising a vest filled with a collection of corks, so that when the individual turns on to the abdomen, discomfort produced by the bag of corks prevents prolonged prone positions with jugular compression and at the same time the weight of this special

attachment is not sufficient to be disturbing, even to a child.

In considering the problem of "noc-

It will be noted that many of the adolescent types possess long, thin necks, small hearts and small vessels. Thus, the cardio-

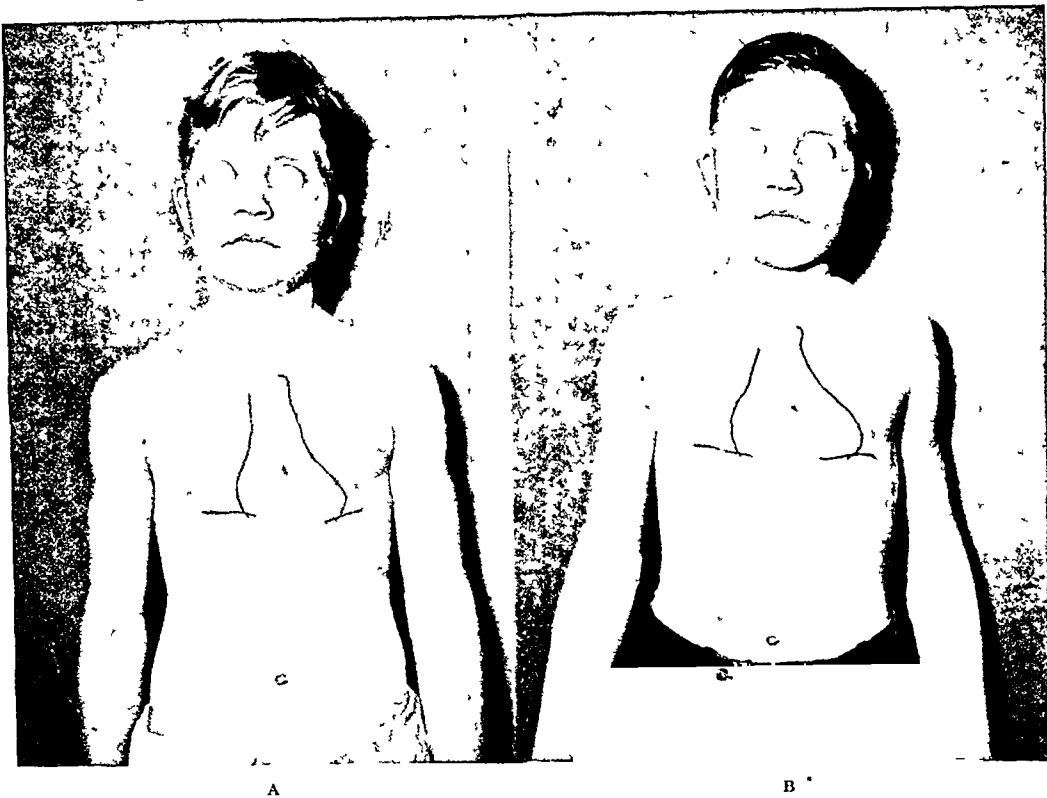


FIG. 6. G. M., male, age eleven. Grand and petit mal since five years of age, averaging as many as fifteen petit mal a day and one grand mal a month. Three grand mal attacks day of admission, August 31, 1938. Neurological examination and laboratory studies were negative. Physique suggests early structural inadequacy type. Encephalogram essentially normal pattern. A, discharged to out-patient dispensary on September 13, 1938 on special epileptic diet, fluid restriction to 16 ounces, phenobarbital gr.  $\frac{1}{2}$  twice daily and exercises to develop chest and heart. Since discharge there has been marked improvement, averaging only one petit mal and one grand mal every other month. Attends school regularly. B, note increase in size of heart and chest after six months of systematic exercises.

turnal" epilepsy, therefore, the clinician must observe or have detailed or illustrated to him the position in which the patient is inclined to sleep, where the hands are placed, and if during the relaxed state of sleep, postures may develop that would press on, kink, or obstruct venous return flow from the brain.

X-ray of the base of the skull (Chamberlain projection) for study of the vascular foramina; examination, measurement and determination of the size and development of the heart; estimating the distance between the heart and vertex as well as the size of the arterial structures will be necessary to evaluate the *degree of structural inadequacy*.

vascular system is required to pump blood further, through smaller vessels into an otherwise normally appearing head and brain, and if occasional failure to sustain adequate circulation ensues, the period of arrested movements of circulation need only be similar to that noted under the "Stokes-Adams syndrome" to favor a seizure.

Correction, if possible, can be assisted only by appropriate exercises. We all recognize "athletic" heart as frequently arising from collegiate sports. Running, rowing, climbing, and appropriate daily activities, will do much to develop a larger cardiovascular system. (Fig. 6.)

If the physician is willing to guide the patient through the period of adjustment from former sedentary life to one of forced activity, discounting temporarily the additional attacks of this period, he will find that such efforts will be rewarded not only by remarkable development of the chest and heart, but with proportionately gratifying clinical results from the standpoint of improvement in the mental state, the requirement of less drugs and with better control of the seizure.

#### SUMMARY

One objective in making the diagnosis is to recognize the attack or seizure as belonging in the field of the *convulsive state*. With this recognition, an attempt at classification of type must depend upon the concept as to the purpose and nature of the seizure.

If the concept of a "defense" reaction against a threatened failure of cerebral circulation is to be adopted, a search for those factors that directly or indirectly concern cerebral circulation, blood volume and pressure relationships should lead to a more accurate diagnosis as to the type, as well as to the direction indicated for treatment.

Where organic processes exist, surgery may be helpful. Where structural inadequacy exists, an active program of physical training, exercise, regulation of fluid, diet and appropriate medication will be beneficial.

Where the symptoms of convulsions arise secondary to some phase of "water intoxication," appropriate regard for the temporary fluid restrictions of the individual must be considered, as well as appropriate measures to enhance elimination through the skin, bowels, and kidneys, and thus prevent abnormally "high tides" of fluid being retained within the cranial cavity (reciprocal low tides of blood).

Finally, it may be pointed out that although fluids, *per se*, are not directly responsible for the seizure, they may displace blood volume and impair intracranial circulation to such a degree that the controlling centers are released more easily by appropriate stimuli and, therefore, certain individuals at certain times become more "vulnerable" to seizures where cellular permeability, altered brain metabolism and other organic and structural factors have also helped to *predispose* them to an attack.



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## Editorial

### THE IMPORTANCE OF A KNOWLEDGE OF VASCULAR SURGERY IN WORLD WAR II

MILITARY and naval figures detailing the severe and fatal injuries at Pearl Harbor brought home to American surgeons the terrifically destructive effect of the modern bomb. The number of those killed equalled the number wounded and this relatively high number of fatalities in relation to the total men injured was a new experience to us all.

One of the surgeons present at the bombing reported that of 600 admissions to one hospital, approximately 400 were of the type classed as serious. He was present at all major offenses in the last war, but never saw such a high percentage of serious injuries.

The surgeons of the Army of the United States and the Navy, hastily summoned from hospital and civil practices, will be confronted, therefore, not only with voluminous traumatic surgical problems, but in 75 per cent of the instances, major wounds. The transition to military surgery will be difficult and in no field more so than in the understanding of the underlying vascular problems. The decision whether to amputate or not must be made by the operating surgeon and on the correctness of his choice will depend the limb and often the life of the injured man. Experience in

large vascular clinics demonstrates that training along vascular lines has been neglected, not only in medical schools but in hospital and postgraduate training as well. It is too late to supply this training to these transformed military surgeons except in a very general way.

The life of an individual or any of his parts depends on the blood supply. Nature has protected his life line by an adequate supplementary blood system which functions when the main one is injured. This system temporarily carries the nutrition. If judiciously stimulated, in many instances it will function permanently. One misconception requiring correction is that laceration or loss of a part of a major vessel necessarily requires amputation of the extremity. Large arteries may be sutured and the circulation restored even after several hours have elapsed. The suture material and needles must be fine and must not enter the intima. Very few sutures are necessary, as the pressure on the vessel wall is inverse to the rate of flow. By removing the vessel from its bed and flexing the limb, defects up to 4 or 5 cm. may be overcome and the artery sutured end-to-end. Contiguous vein tissue may be used as an arterial transplant to replace sections

of arteries. This type of surgery has been successful, particularly since the introduction of heparinization and the new drug, dicoumarin. Perivertebral sympathetic nerve blocks with novocaine solution, producing sympathectomy effect not only relax spasm in the vessels, permitting restoration of this circulation, but also dilate the vessels of the collateral circulation and thus help maintain the nourishment of the part. Judicious application of a tourniquet just proximal to the laceration or the use of a clamp on the vessel itself, may permit circulatory restoration, if not maintained for too long a time. The tourniquet, if used, should cause minimal trauma and should be well padded. A tag with the hour and minute it was applied should be attached.

When the major vessel has been tied or its re-establishment is impossible, the limb is not necessarily lost. The fact that patients with thrombo-angiitis-obliterans and arterial sclerosis, in whom the major vessels are closed, can have their collateral circulation so stimulated that amputation is unnecessary, is a point to be kept in mind before amputation is decided upon. In these

instances ligation of the accompanying vein reduces the incidence of gangrene.

Four factors in the stimulation of collateral circulation are: (1) External controlled heat; (2) vasodilating drugs, such as whiskey, tissue extracts such as depropanex and smooth muscle relaxing drugs like papaverine, atropin, and opiates; (3) The abstinence from tobacco. This latter is most important and bears emphasizing at the time of a major blood vessel injury. The practice of giving "smokes" to every wounded man is no more logical than the use of nicotine by the patient in the operating room; (4) perivertebral sympathetic nerve block.

The prevention of tetanus by the use of toxoid and of gas gangrene by débridement, the sulfa drugs, serum and the nonwound closure technic will all aid in the reduction of mortality.

A week's review of the vascular system and its relation to trauma under expert tutelage for men departing for active service, might be a sound investment for the return of more men to civil life with their limbs intact.

GERALD H. PRATT, M.D.



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# Original Articles

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## WAR SURGERY

### FOREWORD

THIS War Surgery Symposium was presented at the regular monthly meeting, of the Medical Society of the County of New York on February 23, 1942. Each participating speaker was allowed ten minutes, and the underlying motive was to stress the treatment concisely and not the diagnostic features of the chief casualties of war. It was recognized that in a raid on our civilian population, many similar injuries might occur, and thus what follows is in reality applicable to the military as well as the civilian surgery of wartime. Purposely, nothing of first-aid character was stressed, nevertheless much information regarding so-called minor injuries is inferentially included. The participants are practitioners and teachers in their respective fields, and all of them had previous experience in World War I.

A summary of these five\* presentations may be said to emphasize the following basic factors: (1) The importance of early receipt of the wounded; (2) adequate preoperative treatment to overcome shock and hemorrhage; (3) careful cleansing of the wounded area; (4) débridement; (5) use of the sulfonamides in the wound and by mouth; (6) the use of no sutures, or primosecondary suture; and (7) diligent after-care.

Naturally, certain pertinent details are given in the individual presentations, but all the speakers were in accord as to the treatment of the initiating wounds, irrespective of their site, size or severity. This unanimity of opinion should be helpful in standardizing methods of treatment in the casualty groups discussed and which include the great majority usually encountered. These articles are published in the order of their presentation.

\* Dr. Byron Stookey, whose paper has not arrived in time for publication, gave an excellent presentation of the method of transporting patients with spine injuries.



# WAR WOUNDS

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IT will not profit us to discuss the classification of war wounds as to source, site or size except in general terms. The current casualties are from bomb fragments and machine gun bullets in contrast to those caused by shrapnel, grenades and rifle fire so familiar in World War I. Nor is there special clinical gain by classification in terms of penetrating, perforating, tangential or other types of war wounds.

The essentials are to combat the *three horsemen of trauma*, namely, *shock, hemorrhage and infection*. Shock and hemorrhage are best defeated by such surgical ammunition as external heat, fluids, and the sovereign power of whole blood, or liquid or dried plasma. Before World War II is won, my belief is that stored blood will be in the form of capsules or tablets and perhaps even some modification permitting the use of animal blood already endowed to offset the prevailing organisms of the germ infested terrain now actually world-wide.

The treatment of the wound itself has two main objectives: one to prevent infection, the other to promote healing. We know that organisms survive only in the presence of dead or dying tissue. If we can have live tissues, we are assured of dead germs, irrespective of the source, site or size of the wound. Further we know there are two phases in our combat; one is the *contamination*, the other the *infection* phase of any wound. Hence the time element in our fight is important. Long ago we learned that any trauma treated early usually meant victory; but if treatment lagged, we yielded to complications that often meant defeat. This time element leading to victory is within the first six hours post-trauma, the Golden Period. Wounds treated then are in the *contamination phase*; treated thereafter they are in the *infection phase*.

The basic elements in wound treatment may be said to be: (1) The *time element*—within six hours post-trauma; (2) the *cleansing element*—soap and water and more soap and water until the parts are cleansed after the manner of preoperative cleansing of our hands; (3) the *excising element*—débridement. This means the removal of all damaged tissue by non-sacrificial excision until three criteria are attained: (a) the parts look healthy, (b) bleeding is present from the excised edges, and (c) muscle contracts. This process is not in terms of amount of tissue removed; it may mean one-sixty-fourth of an inch or three-fourth of an inch until the named criteria are attained. (4) The *hemostatic element*—leave the wound dry because blood, serum and macerated tissue become an autogenous culture medium, virtually a bouillon to promote growth of organisms. (5) The *sterilizing element*—place on and in the wound a sulfonamide, preferably sulfanilamide. In amount this should coat the entire area liberally. Too much rather than too little should be applied. (6) The *suture element*—if the wound is of the lacerated type, abandon any idea of suturing it; instead place the sutures but do not tie them until the third day if all goes well. This is primosecondary suture and it is by far the best form of treatment for ordinary wounds from any source. In wounds that are very deep or very ragged, the area is left wide open and no suturing of any type is used. (7) The *dressing element*—heavy gauze and cotton applications are used because rest and immobilization are important factors. If joints are contiguous, they should be splinted to provide additional immobilization; then the parts should be elevated and tilted if possible to promote drainage. (8) The *after-care element*—a sulfonamide is given by mouth, and our

practice at Pearl Harbor was to give 15 gr. of sulfanilamide each four hours for three days postoperatively. No redressings are done until the third day unless there are contraindications.

All redressings should be done with great care to avoid re-infection, hence a sterile clamp and thumb forceps should be used so that no soiled fingers or hands will contact the area involved nor touch any of the dressings. This is a blacksmith's technic because he uses tongs to touch his operative field and to handle his red hot material.

For the ordinary wound—the abrasions and scratches of the skin-deep variety—the routine is the same as far as the time element, the soap-and-water cleansing element and the powdering of the area with a sulfonamide are concerned. As to suturing this type, we may say that *primary or immediate suture* is permissible in recent superficial wounds that are well cleansed. However, the interrupted sutures should not be too numerous nor tight, and safety is added if a drain is inserted, such as a rubber band or a pipe cleaner. Drains, as a rule, should be removed within forty-eight hours.

However, in this superficial group if there is soil or débris contamination, the practice of primosecondary suture is best. As a matter of fact, the alignment obtained by this procedure is satisfactory enough even from a cosmetic standpoint.

*The Infected Wound.* These are the cases in which the pus-producing organisms or others have already established themselves. The typical signs such as pain, redness, swelling and systemic symptoms exist. Most cases are of the combined staphylococcus-streptococcus group. Less frequent are such invaders as gas gangrene and tetanus.

For the usual case manifesting pus secretion and cellulitis the treatment is:

(1) Provide exit for retained secretion by removing sutures if present.

(2) Apply wet dressings of 3 per cent sulfanilamide in water. Keep these moist

by attaching tubes to a reservoir, and keep them hot by electric bulbs.

(3) When localization occurs, incision is indicated only if and when (a) local fluctuation, (b) local induration and (c) local pain exist. Let the incision be long enough and deep enough to provide self-gaping. For drainage use gauze only if bleeding is free or the edges have to be separated. Soak this gauze in 3 per cent sulfanilamide in mineral oil. Do not ram gauze into any wound; that is not surgery, it is taxidermy. Do not incise alone for such symptoms as brawny induration, redness, red streaks or adenitis. If we incise for these indications, we may increase and not decrease the process; and what is more, we may produce a blood stream invasion by our effort.

(4) Give a sulfonamide by mouth, 15 gr. every four hours for three days.

Gas gangrene involvement was treated at our Pearl Harbor formation by liberal débridement, repeated x-ray exposure and sulfanilamide in the wound and by mouth. We used serum in only a few of our eleven cases. All our wounded recovered without re-amputation, and in every case of this infection, sutures had been used. Tetanus yields usually to serum, but we must not forget that débridement and sulfanilamide locally and by mouth are necessary adjuncts.

In any infection, the combating and sustaining power of transfusion dominate the program.

Thus to sum up, we treat war wounds in terms of: (1) Time, (2) soap and water cleansing, (3) débridement, (4) primosecondary or no suturing, (5) sulfonamides locally and internally, (6) adequate dressings, (7) careful redressings, (8) blood for shock and infection, (9) no secondary incisions except for localization, (10) débridement, sulfonamides and x-ray for gas gangrene, and (11) antiserum for tetanus.

Just a word or two regarding substitutes for the proved-by-experience sulfonamides. We are beginning to hear of the earth-born derivatives called *pencillin* and *gramicidin* and these may prove in the future to be



potent weapons in our surgical war. But until these reinforcements arrive, let us rely on the ammunition that continues to render such valiant aid—the *sulfonamides*. We should take every advantage of these weapons that so effectively kill our germ enemies. Let safety first be our guide, and to that end suspect *every* wound of being hostile until proof to the contrary is demonstrated.



A PROPER examination after a pelvic injury should never omit inspection of a sample of urine (by catheter if none can be voided). If bloody urine is found, a catheter should be inserted and the bladder washed with salt solution. In this manner it can be determined if the bleeding comes from kidney, bladder or urethra.

From—"A Manual of the Treatment of Fractures"—by John A. Caldwell (Charles C. Thomas).

# FRACTURES SUSTAINED IN WAR

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THE treatment of simple fractures under war conditions differs in no way from their treatment in ordinary life. First-aid protection, early reduction and proper immobilization are the main indications.

According to the statistics of the last war as published by Love, the casualties of the U. S. Army showed that 54 per cent were soft part wounds of the extremities, 29 per cent were compound fractures of the extremities, 9 per cent involved head and spine, with involvement of chest and abdomen 1 per cent each. The compound fractures, therefore, are a most important group.

The pathological status of these compound fractures produced in war differs from that encountered in civilian life in several ways: There is much greater comminution. Instead of two or three fragments, an area of 5 to 15 cm. of bone will be completely shattered with a corresponding amount of soft part damage. With rifle or machine gun wounds the soft part damage and contamination may be minimal but in cases produced by shell and bomb fragments the damage is often extreme. The large, lacerated wounds contain bits of clothing and other foreign bodies. Another difference between the civilian and war problems is that of transportation, which has an important bearing on treatment. In civilian work the first trip the patient has may be long and difficult but once he arrives at a hospital he can receive his surgical treatment and then be kept quiet as long as may be necessary. Under war conditions treatment is often interrupted by several moves in the first few days and the treatment must be planned to meet this difficulty.

Even with these differences in the pathological condition, the fundamental

principles of treatment of compound fractures sustained in war are the same as those encountered in civil practice. These principles are based on the facts that we are dealing with individuals who have received injuries to their bones and soft parts, with open wounds communicating with these injured areas and with contaminating material introduced into the depths of the wound. The Army Medical Corps can do nothing to control the extent of the original injury but it can do a great deal to reduce the amount of secondary trauma the wounded man is exposed to after he has been hit. The object of the first-aid treatment is to reduce this secondary trauma to a minimum. This involves protection of the wounds, early splinting and the use of chemotherapy at the earliest possible moment. The British Army in the last war reduced their mortality in compound fractures of the femur, from 50 to 15 per cent by the application of Thomas splints by the stretcher bearers. The reports from Pearl Harbor of the delay in the spread of infection by the early use of the sulfa drugs are most encouraging. The results of tetanus toxoid immunization promises even to surpass the efficacy of the use of antitoxin.

The second principle is the operative treatment of the wound at the earliest possible moment. In addition to the broken bone there is lacerated muscle and fascia, much of it damaged beyond repair. This dead and dying tissue furnishes ideal conditions for the growth and activity of the contaminating pathogenic organisms introduced into the wound. These must be removed by careful dissection and irrigation. Surgical cleansing of the wound, called débridement, needs extreme care and gentleness in order to lessen the secondary trauma and to avoid spreading the contamination to the deeper planes. Under

complete anesthesia and with traction maintained, the wound is protected by gauze while the surrounding skin is thoroughly but gently scrubbed with soap and water. The injured part is then draped and the excision of traumatized tissue and foreign bodies carried out with sharp dissection. This is done in layers with frequent change of instruments. At the same time the wound is irrigated with plentiful amounts of saline solution. Four quarts is a minimum amount. In irrigating the deeper planes, the sides of the wound are retracted and the nozzle introduced so that the flow will be from within outward. The object is to wash *out* the wound not to wash *in* contaminating material. The débrided tissue should be put into a sterile container for aerobic and anaerobic cultures to establish the character of the contaminating organism. On completion of the débridement, salt solution from the depths of the wound should be cultured to test the efficacy of the operation. The result of these cultures will be of help in deciding on the future treatment of the wound.

The next problem is to bring the bone fragments into normal alignment and to apply dressings to the wound. At this stage, one of the protective drugs is introduced into all the planes and crevices of the wound and the surfaces separated by vaseline gauze. Although some surgeons are of the opinion that these wounds can be closed if seen early and properly débrided, I believe strongly that they should be left open. Many successful primary closures are reported but when they are not successful the results are often calamitous. Tension within the wound favors bacterial growth.

Which of the various sulfa drugs or zinc peroxide is the most efficacious for local use in these wounds is still a debatable point to be established by further experience. Apparently, if one of the sulfa drugs can be introduced into the wound as a primary dressing procedure and the oral administration started at the same time, the surgical treatment can be carried out with success at a much later period than if the drug is not used. Six to eight hours was formerly thought to be the safe period without the use of those drugs. With their use such treatment may be successful after even two or three days.

The next step in treatment is the immobilization of the injured part. This can be accomplished by traction and suspension, by circular plaster splints alone, by wire or pin traction, the wires or pins being incorporated into plaster or into some external appliance such as the Roger Anderson method or by rigid internal fixation by plates and screws. These various methods have been enumerated in the reverse order of their efficiency. Suffice it to say that the constantly repeated movement of the bone fragments during transportation and dressings is a large factor in the spread and continuation of infection.

#### SUMMARY

Compound fractures form a large percentage of war wounds. Although the pathological status is more complicated in war wounds, the principles of treatment are the same: (1) first-aid protection of wounds, early splinting, early use of drugs, (2) operative cleansing of the wound at the earliest possible moment, (3) reduction of fragments and (4) immobilization.



# BRAIN INJURY IN WAR

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RECENTLY it has been proved experimentally by Denny-Brown that a head injury, in order to produce unconsciousness, must cause an acceleration of movement of the brain, either positively or negatively, to the extent of at least 28 feet per second. Such shaking of the brain usually does not occur if the skull is penetrated by a metal fragment going at high speed. Therefore, a man injured in this manner, if unconscious immediately, has usually been made unconscious, not by the impact of the missile but by the missile having ploughed through such an extensive area of brain tissue as to make it extremely unlikely that he can be saved. On the other hand, a nonpenetrating blow on the head will often produce immediate unconsciousness without necessarily having destroyed or perhaps even injured permanently any brain area. In fact, I have seen an officer suddenly go blind during the last war, who denied to me that he had been hit. All he knew was that daylight had been replaced by complete blackness. When I found the pupils fixed, I knew his blindness was organic, but I failed, in the trench, to find any sign of a wound on the scalp. Later, at the casualty clearing station, a tiny, crescent-shaped, red hairline was found above the hairline on the temple and x-ray examination revealed a minute sliver of steel placed squarely in the optic chiasm.

The size of entry in the skull is usually small and circumscribed; the inner table is apt to be shattered and bone fragments from it carried into the brain. The wound in the dura may be still larger by reason of both steel and bone fragments. The cortical vessels are torn; a hematoma may form along the track of the missile.

The treatment of these wounds has changed since the advent of sulfanilamide and its "cousins." I remember seeing more

than thirty brain abscesses at a time in a single base hospital in the last war.

If brain injuries are treated early, it is possible now to prevent their infection. It is, therefore, important that head injuries be cared for near where they occur and a more or less routine procedure for their treatment can be produced.

*Procedure of Treatment.* (1) The hair should be clipped and the scalp washed with soap and water. (2) A local anesthetic, such as procain hydrochloride, should be used; do not use morphine. (3) Large vessels should be caught with hemostats or by rubber tubing placed around the forehead. (4) Wounds should be filled with sulfanilamide or sulfapyridine; débridement should be effected as well as possible. (5) Antitetanic serum should be given. (6) Treatment for shock should be instituted immediately and operation ought to be delayed for twenty-four to thirty-six hours. Patients should be sent back to where x-ray facilities are available and then operated upon. Such a "head station" should be as near the front area as is militarily possible.

If the injury is treated early, the wound promptly filled with sulfanilamide and if it is not too large, the patient will probably survive.

It is now possible to treat such patients with a closed operation, the scalp being undercut and closed with interrupted sutures. For hemorrhages from dural vessels mosquito clips are best; avoid the cautery for these. The dura should be closed with a periosteal patch, especially if paranasal sinuses are involved. Suck out the blood clot in the track of the missile and irrigate with warm saline. Exploration is best carried out, not with the finger, but by means of a rubber catheter as Cushing taught us. Any wound big enough to be explored with the finger is hardly worth

exploring. Finally, the track should be filled with sulfanilamide powder before closure. Do not be too squeamish about leaving inaccessible bone or metal fragments. One may do more harm by taking fragments out than the enemy did by putting them in.

After this procedure, sulfanilamide drugs should be continued. Luminal therapy should be started at once and an instruction tagged on the patient that luminal should be continued for a year more, because of the possibility of convulsions appearing within twelve or fifteen months.

If the wound has to be reopened for drainage, gauze impregnated with sulfanilamide or sulfapyridine should be used. On the whole, in these cases sulfapyridine is to be preferred to sulfanilamide as it has proved to be less depressing to the brain cortex.

If by the mischance of war or poor management the wound has not been treated in the manner described within forty-eight hours, it must be treated as an infection, that is, an open wound, as was habitual in the last war.

Since the effect of rapid closure is to produce increased pressure and acute cerebral edema, one must be prepared to deal with these by dehydration measures, including 50 per cent sucrose solution, caffeine, sodium benzoate, and if available, concentrated serum, given intravenously. This concentrate is prepared by adding 40 cc. of sterile distilled water to the dry solids obtained from 200 cc. of human serum, shaking well and incubating for one hour at blood temperature. Serum obtained from pooled blood requires no blood grouping. It is recorded that in one case pressure fell from 275 to 80 mm. within twenty minutes after the use of concentrated blood serum, rising later to a normal level of 110.

Although in the last war the mortality rate after brain injury was said to be 60 per cent, I myself thought it was more. I saw somewhere that Cushing by means of his technic had lowered it to 28 per cent, but this was probably only on his own cases.

I remember, just after the battle of Messines Ridge, I met Sir Anthony Bowlby on a road near where Cushing had been provided with a "head hospital." I asked General Bowlby how Colonel Cushing was doing, and he replied enthusiastically, "He is doing beautiful work, but he has only done 8 cases in a day. We shall have to ring the Germans on the telephone and ask them to call off the war to give Cushing time to catch up!" We must remember always, in making our plans, that there is a war on. One must work fast when convoys of wounded are pouring in, perhaps under fire, and orders to evacuate may come in the middle of an operation; so, one must be swift to change methods.

In basal fractures, it is well to remember that the dura is firmly attached to the basal portion of the skull and, therefore, is nearly always torn. There is danger in these cases of the fracture being compounded into the nose, ear or accessory sinuses, with subsequent risk of infectious meningitis. If an x-ray can be taken and discloses intracranial air, the compound nature of the injury is proved. I once saw a lady in Paris who fainted suddenly, falling forward on her forehead. She was immediately unconscious. When an x-ray was taken a perfect ventriculogram was found; a fracture of the posterior wall of a frontal sinus had allowed air to whistle into the cranial cavity, fill the ventricles to distention, so that at the American Hospital she was accused of amnesia for a recent lumbar puncture with air injection.

All cases of stiff neck do not necessarily signify infectious meningitis, since this may be produced through seepage by gravity of subarachnoid blood. If one has the chance of doing a lumbar puncture to establish the presence of blood in the spinal fluid, this should be done, except in those cases in which leakage of spinal fluid from the nose, ear or sinuses, or bleeding from the ear or nose have demonstrated the presence of basilar fracture.

The tomograph, an instrument by which roentgenologists can visualize and localize

structures and foreign bodies in three dimensions, should be part of the equipment of every base hospital. The use of electric magnets for the extraction of fragments was common in the last war, and I understand is still being used, but this is a base hospital operation and has its limitations.

The following are a few suggestions: (1) The bladder of any unconscious patient should be closely watched. (2) Sulphur containing drugs, like epsom salts should not be used if sulfanilamides have recently been given. (3) Where flying ambulances are used, patients who are receiving sulfanilamides or related drugs, should not be transported at high altitudes, lest sudden death occur from lack of oxygen. (4) Patients with compound fractures into the nose must be instructed not to blow the nose. (5) When burns occur, hydrosulfosol may be used as a spray; diluted 1:20 it may even be used for the eyes.

At the beginning of this paper, I have tried to outline a procedure for penetrating head injuries. I should like, in conclusion, to add a similar outline for the care of non-penetrating head injury: (1) Treatment of

shock by the intravenous injection of 100 cc. of 50 per cent hypertonic glucose solution or blood serum as already described; (2) lumbar puncture for diagnosis and treatment; (3) repetition of hypertonic dextrose by vein to reduce increased intracranial pressure (100 cc. of 50 per cent solution, three times daily); (4) injection of caffeine sodiobenzoate,  $7\frac{1}{2}$  gr. (0.5 Gm.) every four hours (hypodermically); (5) rectal taps of 25 per cent solution of dextrose, 4 ounces (120 cc.) every four hours; (6) elevation of head of bed 15 to 45 degrees; (7) the carrying out of operative procedures in cases suspected of progressive middle meningeal hemorrhage; (8) the use of antimeningococcic serum in suitable cases and antitetanic serum in all patients with a scratch on them; (9) the performance of right subtemporal decompressions in comatose patients with marked papilledema, who do not respond to the aforementioned procedures within three days; and (10) uncomplicated depressed skull fractures may be elevated after the acute stage of shock has passed. Surgical interference in this group may often be safely postponed for many days.



# OUTLINE OF TREATMENT FOR SEVERE WAR WOUNDS OF THE CHEST

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WOUNDS of the chest related to bombing offer no special surgical problem because the devastating effects of hurled fragments of glass or stone are analogous to those of flying fragments of high explosives. Although the character of chest wounds thus remains essentially unchanged from that of the first World War, considerable difference in treatment should be anticipated because of the advances in thoracic surgery in the intervening two decades. The advances have been in three principal directions: (1) a better understanding of cardiorespiratory physiology, (2) positive pressure anesthesia, particularly with the newer anesthetics and (3) the technic of removal of large sections of pulmonary tissue. In this outline of management of thoracic wounds I propose to indicate the part which I believe these advances should play.

As in other serious wounds, the effects of shock and hemorrhage often are to be combatted in the initial phase. There are two features inherent in all serious thoracic wounds which create special problems: (1) the agitation of a rigid yet constantly moving bony cage, and (2) the likelihood of interference with the function of the heart or the lung, or both. Significant effects of the severer injuries can be briefly enumerated: (1) air in the pleural space with or without blood, (2) bleeding into the pleural space which tends to continue if the lung collapses, (3) sucking wound with increasing intrapleural tension and mediastinal shift and (4) bleeding into the pericardial sac and cardiac tamponade.

Diagnostic questions are here omitted yet emphasis should be placed in season and out of season on the fact that grave damage may result from an apparently insignificant penetration or, put in another

way, an insignificant penetration has usually inflicted grave damage if shock has been induced.

The surgical management of a serious thoracic wound should be related to the time and place of first treatment, the urgency of the case and the availability of special personnel and equipment. General treatment will not be considered. The primary requirements for the local lesion are: (1) morphine, regardless of a possible untoward effect on cough or respiration, (2) for a sucking wound, tight packing and strapping and (3) for hemorrhage from the thoracic parietes, tight packing of the entire tract in the chest wall. Incomplete emergency operations, such as the suturing without débridement of a sucking wound, are to be deplored. If the patient is suffering from tension pneumothorax after emergency packing of the wound, the trapped air should be at least partially withdrawn by any available means. When, however, tension pneumothorax is due to a laceration of the lung, resort must be had to a continuous evacuation of the air. There are two excellent methods for this purpose: closed drainage under water into a bottle situated considerably below the level of the chest or, especially for a patient to be transported, an intercostal tube with attached flapper valve as devised by Lilienthal.

An urgent condition which calls for immediate surgery whenever possible is cardiac tamponade due to a penetrating wound of the heart. In addition to the picture of shock its evolution is characterized by a progressively smaller pulse with corresponding drop in the blood pressure, distended veins in the neck, and a silent heart. The absence of cardiac pulsation, which is the essential operative indication, can be established unequivocally only by

fluoroscopic examination. Lacking such confirmation, and in the absence of specially trained medical personnel, nonoperative treatment is probably safer.

Indeed, specially trained personnel (surgeon and anesthetist), as well as special anesthesia equipment are eminently desirable for all major primary thoracic operations. If not available, I believe that routine conservative treatment, which was generally practiced and yielded a measure of satisfactory results in the first World War, is in order. Makeshift operations or operations by those without experience should have no place in this field. Given a trained operating team, thoracic wounds in general offer an unusually favorable field for early and complete recovery, much more favorable than cranial or abdominal wounds, for example. The objective should be the restoration of cardiac function and full expansion of the lung. There is thus avoided the intrathoracic crippling which is prone to occur from organization of retained blood clot and exudate. Indications for a primary operation by a trained team are (1) continuing hemorrhage, (2) the definitive closure of an open pneumothorax, (3) laceration of the lung, (4) removal of foreign bodies, and (5) a wound of lung and/or of chest wall requiring débridement.

Positive pressure anesthesia is imperative for primary intrathoracic operations, in my opinion, because expansion of the lung is to be achieved from the outset if possible. Cyclopropane is a particularly desirable anesthetic in this field. Intratracheal anesthesia has been recommended but appears to me to be unnecessary even for the most extensive operations. Positive pressure anesthesia with the customary mask makes possible the safe opening of the thoracic cavity to any desired extent. The removal of foreign bodies and débridement of the lung are facilitated by at least partially controlled respiration (carried out by the simple expedient of rhythmic pressure on the bag). Extensive pulmonary lacerations may require partial or complete lobectomy or

even pneumonectomy. Scarcely any primary thoracic operation would be terminated today without pleural poudrage with one of the sulfonamides. Most thoracic wounds should be completely closed; when accumulations of air or blood are to be anticipated, closed under-water drainage toward the bottom of the chest is a safety measure. Special requirements after operation may be (1) the administration of oxygen by means of a mask, (2) bronchoscopic suction which may be life-saving in cases of accumulated secretion in bronchi and bronchioles, and (3) the control of abdominal distention chiefly by the passage of a Levin tube.

Turning to the question of the treatment of major thoracic wounds which do not require primary operations, many perforating rifle bullet wounds, for example, the chief problem is the management of hemothorax. The simple withdrawal of fluid is advocated by some, with the addition of air replacement by others. In either case it should be noted that prolonged retention of blood may lead to crippling peripulmonary fibrosis, to pleural infection, or to both.

While primary operations deal with recently inflicted wounds, secondary operations are concerned essentially with infections in the pleural space. Single encapsulations of pus are unusual. Therefore, careful preoperative study of x-ray films are necessary in order to locate the foci of infection which will be encountered. A liberal operative exposure will usually be required. The problem of traumatic pulmonary abscess, whether due to infection, to foreign body, or to both, requires special consideration particularly from the viewpoint of precise localization in order to achieve accurate surgical approach. Some aspects of non-penetrating wounds of the chest, a subject which has not been touched on, can be referred to only in passing. An atelectatic pneumonia may result from a contusion of the chest wall. Fractured ribs may tear the lung with resultant tension pneumothorax.



or mediastinal emphysema. Crushing chest injuries often are characterized by the lividity of traumatic asphyxia and at times by extreme dilatation of the stomach. A special feature of the present war is the remarkable and horrible "blast injury" of the chest producing extensive hemorrhages into the lungs. These pulmonary lesions apparently are due to concussion or commotion, for there may be no external injury. The stricken individual is in shock, with dyspnea and cyanosis, suffers thoracic

and abdominal pain, and presents abdominal rigidity not accounted for by other injuries.

In the allotted space only injuries limited to the chest have been considered. In closing, reference should be made to concomitant wounds which may require precedence in treatment, and finally, to thoracico-abdominal or abdominothoracic wounds, often of grave significance, in which the abdominal component may and often does require more urgent attention.



THE clavicle is one of the bones most frequently broken. The most common site of breakage is at the junction of the outer and middle thirds where the diameter of the bone is smallest. . . . The fracture is apt to be oblique, rather than transverse.

From—"A Manual of the Treatment of Fractures"—by John A. Caldwell (Charles C. Thomas).

# SURGERY OF ABDOMINAL INJURIES\*

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THE imperative necessity for an army is to conserve and maintain an effective fighting force. The treatment of war casualties will be based largely upon this realistic conception. Wounded soldiers will have received: (a) injuries of such a nature that the army may reasonably expect his return to duty, and (b) injuries of such a nature that the soldier cannot be expected to return to duty. War trauma to the skull and contents, to the chest, grave compound fractures and injuries to the abdomen will be treated without any expectation of the return of the soldier to a combat unit.

The last forty years has witnessed a remarkable change in regard to surgical intervention for war wounds of the abdomen. In the Boer War, the Spanish-American War, and for the first half of World War I, the noninterventionist attitude for abdominal war wounds prevailed. However, with the ability to move modern operating room equipment into the battle zone the interventionists gradually displaced the noninterventionists.

The remarkable advance in modern warfare has introduced types of injuries that were only occasionally met with in World War I. The weight of projectiles and tempo of bombing, added to the dive bombing machine gun attacks have broadened the type and severity of injury. Present day bombs create innumerable secondary projectiles from fragmentation of anything that is in the path of the explosion. Two types of projectiles are thus created: the metal part of the shell, which is jagged, rough and of various sizes, and the secondary projectiles of rubble, metal, glass, and in fact anything and everything that may

be activated and put in transit by the explosion of the bomb. Both carry into the body tissues additional foreign material in the form of clothing and underwear.

In no field of war casualties is the problem of surgical organization so important as in multiple compound fractures, injuries to the skull and contents, thoracic wounds and abdominal wounds. Therefore, surgical organization will imply mobile units that will bring modern operating room technic and equipment into the combat area. These types of war wounds are considered "non-transportable cases" and hence the effectiveness of small, self-contained surgical units, with great mobility, capable of competent surgery within the battle zone.

War casualties of the abdominal viscera are always multiple and severe, always associated with some degree of shock and hemorrhage and many patients will be exsanguinated; all will be complicated by a peritonitis of varying degree and 90 per cent will be associated with perforation of one or more of the viscera. The patients must be transported from the casualty area to the surgical unit. It is obvious that the soldier with minor injuries of the trunk and upper extremities will be able to walk from the battle area to the advanced medical post, while those that are injured in the abdomen will lie upon the battlefield until stretcher bearers arrive to transport them. Except for casualties the result of bombing and aeroplane machine gunning, the field of battle will obviously have to be cleared by an advance of the combat units before the abdominal cases can be picked up and carried back to the most advanced dressing station.

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The surgery for war inflicted abdominal injuries is the application of technical procedures that are in no way different, except in degree, from the principles utilized in civilian traumatic surgery. The fundamental "technics" that are used in civilian surgery on the stomach, intestine and colon are the same surgical procedures that must be applied to the treatment of abdominal injuries sustained in war. These patients will all require adequate preoperative treatment, long anesthesia, relatively prolonged operations, extensive technical procedures, antiperitonitis measures, plus sulfa drugs locally and by mouth; transfusion of whole blood and plasma and parenteral fluids. Furthermore, they will require prolonged hospitalization and post-operative treatment.

The time interval between the receipt of injury and operation and the adequacy of preoperative treatment will determine the mortality. The optimum time for an advanced surgical unit to receive abdominal casualties would be up to four hours and not later than six. There is very little gross soiling of the abdominal cavity even in penetrating wounds of the intestines up to four hours, and there is a relatively slight degree of peritonitis. The patient with an abdominal injury will reach the casualty receiving station: (1) moribund and dying; the indications here are to relieve pain and thirst, (2) in shock, but capable of resuscitation and (3) in fairly good operable condition. A warm body is one of the most reliable objective signs of operability. Refrigeration on the battlefield or in the ambulance during the trip back to the casualty receiving station, combined with shock and physical collapse due to the gravity of the injury and loss of blood, is an almost fatal combination of circumstances. The patient may be suffering from an internal hemorrhage and the only hope of stopping the hemorrhage will be by operative intervention, with simultaneous blood replacement.

Mortality is inversely proportioned to the "time interval period," that is, the

time between the receipt of the injury and the time of operation. Shock, hemorrhage and peritonitis are the outstanding causes of death.

The relative trajectory of the projectile may be visualized in many cases by an examination of the wound of entrance and exit if and when both are present. Deflection of the projectile is to be expected in injuries received in the area of the buttocks or from the thigh upward. The projectile will be deflected and its course deviated by hitting bone or penetrating the bony pelvis. The position of the patient, standing, squatting or lying, the status of the bladder in regard to its fluid content, will also determine the extraperitoneal or intraperitoneal injury of the bladder and rectum. Every patient upon whom a laparotomy is contemplated should be catheterized just before operation as it subserves two purposes: To indicate roughly an injury of the urinogenital system or the absence of urine in the bladder, and finally to have a collapsed bladder during the laparotomy.

The operative indications are more simple than the procedures that will be employed. Every abdominal case in fair operable condition requires surgical intervention. No wound of the external abdominal parieties should be considered insignificant. A projectile may go through five or more loops of bowel and pass through or lodge in the solid viscera. A projectile may not enter the peritoneal cavity but nevertheless produce widespread intra-abdominal injury by the force of impact. Every operation for an intra-abdominal war injury should be undertaken as a complete abdominal exploration.

War injuries of the abdomen may involve one or more of the abdominal viscera. They are usually associated with injuries of the thorax, retroperitoneal tissues including kidney, and with the extraperitoneal portions of the rectum and bladder. Ten per cent of the injuries of the thorax will be complicated by injury to the upper abdominal viscera. Combined thoraco-abdominal injuries passing from side to side

or from the right or the left side, are relatively benign. The projectile may pass through both sides of the costophrenic sinus, traverse the liver on the right side, or the spleen on the left, producing a variable amount of damage to these organs but not perforating the intestine or stomach. Wounds of the stomach will be complicated by injury to other viscera in at least one-third of the cases. Twelve per cent of abdominal injuries will have an associated injury to the diaphragm and chest; 10 per cent will be associated with an injury to the kidney; 10 per cent of injuries to the liver will be associated with injury of other abdominal viscera. The bladder will show a concomitant injury in 5 per cent of the cases and the spleen in approximately 6 per cent. War injury of the large bowel will carry with it a higher mortality and 40 per cent will be associated with injury to other abdominal viscera. The incidence of injury to the retroperitoneal tissues is high whenever the colon is injured. Infection of the retroperitoneal tissues is severe and rapidly fatal due chiefly to the virulence of the anaerobic flora that arises from the colon. The exploration of the colon must be particularly thorough.

The presence of a considerable quantity of free blood in the peritoneal cavity suggests that a main vessel has been injured. Every injured viscus will bleed, the liver and spleen, in great degree, and the finding of a large amount of blood makes it imperative to locate the source of the bleeding at the very beginning of the laparotomy. The abdominal viscera should be explored systematically: (1) the small intestine, (2) the colon, (3) spleen, liver and stomach, and (4) bladder and rectum. All of the small intestine should be inspected from the angle of Treitz to the cecum before any attempt is made to repair the perforations. As each perforation is encountered it should be occluded temporarily by rubber compression clamps for it may happen that five, six, seven or more perforations are all within two or three feet of bowel and one resection will be better than the consecu-

tive closure of a variable number of perforations.

The detachment of the mesentery at its attachment to the small intestine of more than 5 cm. will almost inevitably result in death of that portion of the bowel. Aseptic resection with blinding of the ends and then a lateral anastomosis will be the safest procedure as it is estimated that a lateral anastomosis provides about 10 per cent greater safety than end-to-end anastomosis. In general, the closure of intestinal perforations by enterorrhaphy is attended with less mortality than resection. The danger of a subsequent postoperative intestinal obstruction is not great as a small bowel lumen will suffice for the passage of the fluid contents of the small intestine. If any doubt arises at the time of operation in regard to patency after enterorrhaphy, a lateral anastomosis may be easily and safely performed.

In wounds involving the lateral and anterior abdominal wall the best practice is to complete the laparotomy first and then give attention to the entrance and exit wounds. These wounds should be completely resected by mass excision of the tract with a surrounding area of healthy tissue from the surface of the abdomen through the muscular parietes into the peritoneal cavity. The most practical incision is a midline incision. This incision may be extended either up or down, or laterally, and provides an excellent exposure except for the extraperitoneal portion of the rectum which should be explored by a parasacral incision.

Every injury received in or about the region of the buttocks must be suspected of having injured the extraperitoneal and sacral portion of the rectum. All wounds involving the posterior portion of the trunk and buttocks should receive surgical attention before the laparotomy and not afterward. The turning over of a recently laparotomized patient to take care of posterior wounds is attended with a sudden, pronounced return of shock.

Shock and resuscitation will be reduced by timely and adequate preoperative treatment. Sedation, water balance, whole blood and plasma transfusions will return many patients to a fairly operable condition. Peritonitis, retroperitoneal infection and gas infection will be combatted by the administration of the sulfa drugs by mouth or intramuscularly and by local application. Death from hemorrhage may be prevented by prompt transportation, adequate preoperative treatment and timely surgery.

The effectiveness of abdominal surgery for war casualties and the final outcome of the salvage of lives will depend largely upon the organization of the advanced surgical units that must take care of the grave nontransportable casualties. Low mortality will depend upon (1) available transportation and accessibility for transfer

in and out of the combat area, (2) well trained ancillary groups for the treatment of shock and hemorrhage. These terms will be concerned with preoperative preparation—the treatment of shock—the giving of whole blood or plasma transfusions and parenteral fluids, (3) a highly trained, experienced operating unit of individuals that have worked together over considerable periods and (4) sufficient facilities for the longer hospitalization after operation than obtains in the other fields of war surgery.

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# THE POTENTIATION OF THE SULFONAMIDES IN THE LOCAL THERAPY OF WOUNDS AND SURGICAL INFECTIONS BY THE USE OF OXIDANTS\*

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ALTHOUGH it is more than thirty years since Gelmo<sup>1</sup> synthesized sulfanilamide, and almost ten years since Foerster's report,<sup>2</sup> only seven years have elapsed since Domagk<sup>3</sup> published his classic contribution which has signalized a new era in medicine. In this comparatively brief interval there have been more than two thousand references concerning this new series of chemotherapeutic agents. Literature, however, up to very recently, was marked by the paucity of reports concerning topical use in surgery. The writer has been, for the past ten years, particularly interested in problems of wound healing and in management of surgical infection. Shortly after Domagk published his classic, we reported on the use of the chlorine antiseptics of low potentials.<sup>4,5,6</sup> It was quite natural, then, to turn our attention to this remarkable compound and investigate its usefulness in the management of wounds. Thus, for several years, we have been concerned with the study of the local application of various sulfonamide drugs in the search for the most effective means of utilizing their remarkable antibacterial powers.

At the onset of this work, several questions presented themselves: Are the sulfonamides effective in local wound therapy? Is healing inhibited *per se* by the sulfonamides? Are the sulfonamides absorbed into the general circulation when applied locally to wounds? What is the most effective means of applying these drugs? What is the rationale for the most effective mixture? What are the indications and

limitations to their use? Are idiosyncrasies encountered? What is the mode of action?

This study covers several years' observations, during the course of which we were compelled to overcome the desire to report our findings, by the greater desire to confirm by repeated observations, the conclusions which we believe are now amply substantiated.

## LITERATURE

At the inception of this study we could find but few references to the local use of the sulfonamides. Amongst them were Jaeger,<sup>7</sup> Sinclair,<sup>8</sup> Jensen et al.,<sup>9</sup> and Bohlmann.<sup>10</sup> Little, if anything, of significance was uncovered except for that found in Jensen's paper. This report of good results obtained in thirty-seven out of thirty-nine cases of compound fractures in which 5 to 15 gm. of sulfanilamide had been placed in the wound may be considered the first significant report; we have been unable, however, to confirm the high concentration (up to 800 mg. per cent) they obtained in the local fluid. Bohlmann, earlier, in 1938 used sulfanilamide orally in surgical cases with favorable results but found no brief for his attempt at local application. As competent an observer as Lockwood<sup>11</sup> in October, 1940, reviewing the possibilities of sulfonamide therapy in surgical infections, surveyed the field with hardly any mention of local use. Thus we entered an almost virgin field for the cultivation of our ideas in local application of the sulfonamides. The main thesis of this paper suggested itself early, particularly in the light

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of our previous experience with a chlorine agent in wound therapy.

During the past two years, with the stimulus of war casualties, more attention has been drawn to the local use of the sulfonamides. The British surgeons lately have been particularly concerned with the possibilities in this mode of therapy. Buttle<sup>12</sup> found that sulfanilamide applied directly to the wound will be eliminated in two to three days and advised oral medication with it. He stated that no other antiseptic should be applied. Key and Burford<sup>13</sup> found no retardation of experimental fracture healing when sulfanilamide was implanted. Herrell and Brown<sup>14</sup> reported favorably on its use in infected wounds and noted that the higher local concentrations were more effective than those obtained by oral use, with their subsequently low blood levels. They suggested the use of 30 gr. of sulfanilamide to 100 cc. of normal saline as an irrigation. Stuck et al.<sup>15</sup> found its use effective in compound fractures as did Thomson<sup>16</sup> who advised it in conjunction with oral chemotherapy and designated it as a "Sixth Commandment" for the treatment of compound fractures. Eisenhower<sup>17</sup> applied it in teaspoonful amounts to joint capsule and other wounds in war casualties. Mayo<sup>18</sup> used solutions of sulfanilamide as an irrigation for wounds. Other investigators<sup>19-22</sup> confirmed the favorable results in compound fractures.

The intraperitoneal use of sulfonamides in peritonitis and appendiceal abscesses has become, by this time, a common procedure. Five to 12 Gm. of the sterilized powder are placed in the peritoneal cavity. Dees,<sup>23</sup> Mueller,<sup>24</sup> Rosenberg and Wall,<sup>25</sup> Thomson et al.<sup>26</sup> and others have reported success in this manner. Hawking<sup>27</sup> made an excellent contribution in his investigation of experimental gas gangrene and indicated sulfathiazole as the most effective agent. Bonnon and Fenner<sup>28</sup> have reported indications for the local use of sulfanilamide in prophylaxis of this type of infection. Casberg<sup>29</sup> implanted crystals in eighteen cases of herniorrhaphy and noted no infec-

tion or retardation of wound healing. Johnson and Davis<sup>30</sup> applied sulfanilamide to a variety of wounds with diminution of complicating infection. Cosgrove<sup>31</sup> applied sulfanilamide locally to the eye in normal saline with no evidence of irritation in the treatment of trachoma. Guyton<sup>32</sup> used sulfanilamide as an ophthalmic ointment in the treatment of corneal ulcers.

Dental surgeons were among the first to recognize the value of the local application of sulfanilamide. The local use of sulfanilamide in dental surgery has been reported by Sinclair,<sup>8</sup> Dent,<sup>33</sup> Ziegler<sup>34</sup> and others.

In 1939, when our studies were initiated, we could find but a handful of references to the local use of sulfonamides. The year, 1940, however, found perhaps seventy or more papers on this subject. It is safe to say that this field of chemotherapy will constitute an invaluable addition to the surgeon's armamentarium.

The mode of action of the sulfonamides, either locally or systemically, was, and is, a controversial topic. The comparatively low *in vitro* activity of these agents, when compared with many germicides and antiseptics of surgical practice, early suggested that they operate on an entirely new principle and that they had nothing in common with agents formerly used in combatting infection. The appearance of this new principle in therapy suggested to the writer the wisdom of combining both methods of attack—the new and the old—use of an antibiotic sulfonamide compound simultaneously with accepted agents having antiseptic properties in the ordinary sense.

The clinical results, over an extended period of observation, during which approximately a hundred sulfonamide-plus-antiseptic mixtures were employed, showed a clear-cut differentiation between preparations which gave the more or less anticipated results and those which excelled and exhibited a potency that cannot be easily explained upon a basis of purely additive effect.

*Scrutiny of these antiseptics which appeared to contribute to the sulfonamide*

preparation more than their expected antiseptic values revealed these agents to be, in almost every instance, oxidizing substances. The enhanced effect which they produced in a sulfonamide-treated wound was soon substantiated by *in vitro* experiments. The augmenting effects, moreover, were found to be exerted even by concentrations far below antibacterial levels of the substances if used alone. The antiseptic agents employed during the process of the investigation were of many classifications. (Table I.)

TABLE I

1. Halogens
    - \*a. Iodine
    - \*b. Azochloramid
    - \*c. Di-chloramine T
    - d. Thymol iodide
    - e. Iodoform
  2. Organic mercurials
    - a. Metaphen
    - b. Merthiolate
    - c. Mecresin
    - d. Mercurochrome
    - e. Phenyl mercuric nitrate
  3. Quinones, quinolins
    - a. Hydroxyquinoline sulfate
    - b. Quinoline
    - c. Hydroquinon
    - d. Vioform
  4. Phenols
    - a. Phenol
    - b. Hexylresorcinol
  5. Peroxides
    - \*a. Hydrogen peroxide
    - \*b. Zinc peroxide (ZPO special)
    - \*c. Benzoyl peroxide
  6. Miscellaneous
    - a. H-1 (extract of soil bacteria)
    - \*b. Potassium permanganate
- \* Oxidizing agents.

## CLASSIFICATION OF LESIONS TREATED

We were fortunate in having a large series of cases for study, particularly so because, with only few exceptions, all treatments and observations were made by one individual. This is of more than passing significance where repeated observations are necessary to confirm conclusions. Our cases may be classified as shown in Table II.

## TRAUMATIC LESIONS

This group of wounds may be subdivided into those receiving early and those delayed, treatment. Wounds were con-

TABLE II  
CLASSIFICATION OF LESIONS TREATED

	Cases
I. Abrasions (Preparations Nos. 15, 48, 90)...	37
(a) within six hours.....	11
(b) six hours or more.....	26
II. Lacerations (Preparations Nos. 2, 15, 83)	
(a) within six hours.....	67
(1) scalp.....	28
(2) face.....	16
(3) extremities.....	23
(b) six hours or more.....	69
(1) scalp.....	31
(2) face.....	24
(3) extremities.....	14
III. Avulsed wounds (Preparations Nos. 15, 40).....	19
IV. Puncture—stab wounds (Preparations Nos. 2, 15, 81).....	22
V. Foreign bodies—exploratory wounds (Preparations Nos. 2, 15, 43, 83)...	26
VI. Operative wounds (Preparations Nos. 2, 15, 26, 43).....	162
VII. Hand infections (Preparations Nos. 15, 16, 43, 81, 83).....	182
(a) epiparonychia.....	56
(b) subepithelial abscess.....	15
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pyoderma, impetigo, furunculosis, etc. (Preparations Nos. 15, 48, 90)	
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sidered recent if they were received for treatment within six hours.

Therapy consisted in cleansing and shaving the skin. Tincture of green soap scrubs were employed. The wound itself was then thoroughly flushed with saline and hydrogen peroxide solutions. Where necessary, indicated surgery such as ligation of vessels or repair of severed structures was performed. Devitalized tissues, skin edges, etc., were débrided. Puncture wounds were laid open by unroofing, using criss-cross incisions with elevation of each of the four segments.

In lacerations which required sutures following the peroxide flushing, the depth of the wound was insufflated with the powdered sulfonamide or sulfonamide mixture prior to suture. Of these wounds, a series was insufflated with sulfanilamide or sulfathiazole alone, and another with a mixture of the two powders in the proportion of two parts of sulfanilamide to one part of sulfathiazole. A third group was insufflated with a powder composed of sulfanilamide, sulfathiazole and zinc peroxide in the ratio 4:2:1. Sutures were then applied in the usual manner and a dressing of gauze impregnated with one of the sulfonamide mixtures was applied after the wound margins had again been lightly dusted with the powder. One purpose of the study of this group was to determine whether or not the sulfonamide drugs exhibited any inhibition to wound healing; it is realized that many of these lesions, with adequate surgical care and preparation, might have gone on to primary union in the absence of any sulfonamide medication.

There was no appreciable interference with the rapidity of healing of the wounds treated in this manner as compared with the technic formerly used without the sulfonamide drugs. Not only could we observe no inhibition to healing, but we have not encountered a single wound infection throughout the entire series of sutured wounds thus treated. These included several late and extensive lacerations for

which ordinarily the surgeon would not attempt primary repair.

To cite a case in point, the following report is presented:

A white male of thirty-six years, who, during a street brawl, was struck and caused to fall in such a manner that his ear was torn by the loose chain of a fire hydrant. He was brought to the clinic after lying some time in the gutter. There was a heterogeneous mixture of blood, skin, cartilage and dirt. After a gross cleaning with tincture of green soap and sterile water, the skin edges and lacerated cartilage were débrided. The entire area was flushed with hydrogen peroxide. All of the cut and repaired surfaces were then liberally packed with sulfonamide powder. Reconstruction was then attempted and some thirty sutures were required. The cartilage was approximated by several deep buried silk sutures and the skin edges were similarly repaired. The external dressing was of sulfanilamide two parts and sulfathiazole one part in triacetin (glyceryl triacetate) containing compound iodine solution 1:5,000. Primary union was obtained. Sutures were removed at the end of six days with an excellent cosmetic result.

A point to observe in this particular case was, that in a grossly crushed and dirty wound, contamination was overcome by the use of sulfonamide mixtures and, what is equally important, there was no evidence of any interference with the normal process of wound healing. (Figs. 1 and 2.)

Veal and Klepser<sup>35</sup> reported an impression of delayed healing in sulfanilamide treated wounds, which they believe may be overcome by the addition of a "stimulating agent." Although there appears to be evidence of a slight foreign body reaction locally, we cannot agree that the sulfonamide, thus applied, appreciably inhibits healing. Key et al.<sup>36</sup> report a slight retardation but state that it is not extensive enough to prevent use, even in clean wounds.

One of the simplest and perhaps the commonest of traumatic wounds is the simple abrasion. This, of course, may vary in degree and depth and in area involved. Needless to say, in most cases, simple

cleansing of the part with soap and water is sufficient. Fresh abrasions of this type were seen only when they were rather extensive; otherwise, for the most part, the patients neglected them until the time that they may have become infected. Sulfonamide powders or ointments were applied to these wounds and our observations indicate that they form, with the secretion, a coagulum which became dried and incrustated, depending upon the period of time elapsing between application and subsequent dressing. If left undisturbed for six days or more, healing was found, in most instances, to have taken place without any difficulty beneath this protective crust.

*Puncture Wounds, Stab Wounds.* Puncture and stab wounds, such as those produced by stepping on nails, also other lesions of this type, were treated by criss-cross incisions and unroofing of the inverted skin edges. Powder was packed into these wounds. It was in several instances that, due to the very configuration of the wound and the small amount of available wound surface, the powder was not absorbed readily and acted as a plug. It is advisable, therefore, not to use the powder in small puncture wounds unless, after six hours, the dressing is moistened and kept moist with saline solution.

*Avulsed Wounds.* Avulsed wounds treated with the dry powder presented surfaces which, due to the large amount of tissue fluid, blood and serum, formed a rather definite coagulum. It was first thought that this coagulum might retard healing. However, no such difficulties were encountered. In many cases, the coagulum was gently removed with forceps and in others the coagulum was left undisturbed. There seemed to be little difference in the rapidity of healing in either case. Cytological studies on a series of wound coagula will be discussed below.

*Foreign Bodies, Exploratory Wounds.* In a series of twenty-six cases no infection was encountered following the removal of foreign bodies although in some instances

there was gross contamination and considerable delay from time of injury to removal. A number of sulfonamide prep-



FIG. 1. Grossly contaminated and extensive avulsed laceration of ear in which primary repair with aid of potentiated sulfonamide was attempted.

FIG. 2. Postoperative result ten days later. Primary union accomplished with no inhibition of reparative process.

arations was used in this series, all of them containing as one of the ingredients an oxidizing agent.

#### OPERATIVE WOUNDS

Under this title are included various intra-abdominal and skeletal lesions of graver import as well as a rather heterogeneous group of cases, among them lipomas, fibromas, sebaceous cysts, bursae, ganglia, etc.

In the past, among patients coming to our clinic for redressings following excision of more or less minor surgical entities, we have noted frequent occurrence of wound redness, "stitch" abscesses and even frank purulent infection. The incidence of postoperative sepsis in these minor cases exceeded the usual rate of postoperative contamination in major cases—herniorrhaphies, appendectomies, cholecystectomies, etc.

Much of minor surgery is performed at physicians' offices, out-patient departments and dispensaries. The fact that there should be no sepsis following minor surgical procedures does not obviate the persistent findings in these cases of a high

incidence of complicating wound infection. In these cases, regardless of previous treatment outside, we have adopted and have followed the use of sulfonamide powder and sulfonamide activated impregnated gauze. In our hands, this has markedly reduced the duration of complicating infections.

In a wide variety of clean operative wounds we have observed no retardation of healing with the sulfonamide medication.

The management of postoperative infections following various major surgical procedures is most effective when sulfonamide-oxidizing agent combinations are employed. Adequate drainage is provided by opening the incision as the individual case requires. Débridement of nonviable tissue is carefully carried out. The wound is thoroughly irrigated with hydrogen peroxide. One of the sulfonamide mixtures containing an oxidizing agent is placed in contact with all wound surfaces and then overlaid with medicated gauze squares of packing impregnated with the same mixture. The first dressing is not disturbed for from three to five days depending upon the extent of the infection. The procedure is repeated, progressively increasing the intervals between dressings to a maximum of five to six days. The prompt control of suppuration and the elaboration of healthy granulations is noticeable in many cases at the second dressing. The treatment of postoperative infections by this method has been uniformly good. A case in point is cited:

A fifty year old female had been operated upon for intracapsular fracture of the femur with insertion of a Smith-Petersen nail. The severe postoperative infection which developed had been treated for more than a week by drainage and the local applications of azochloramid in triacetin. In spite of treatment, suppuration continued and it was feared that the infection might finally involve the bone with loss of the nail and subsequent development of an osteomyelitis. Cultures showed *Staphylococcus aureus hemolyticus*. At this point the wound was carefully débrided and we

instituted treatment with an activated sulfonamide mixture (sulfathiazole 10 Gr. to 100 cc. of azochloramid in triacetin). Up to this time dressings had been done daily without control of suppuration. The first redressing following the application of the sulfonamide medication was performed in four days. At that time suppuration had ceased and the beginning of repair by granulation was noted. Redressings were continued at intervals of five to six days and at the end of three weeks the wound was sufficiently healed to allow the patient to be out of bed and ready for discharge to convalescent care.

We suggest, in the face of what we are certain will be marked opposition, that all surgical wounds before closure be flushed with a warm solution containing 1 per cent sulfanilamide and .6 per cent sulfathiazole, with a 1:10,000 compound iodine mixture, and that on completion of closure the wound edges be covered by a strip of medicated gauze. This is particularly desirable for operations of long duration accompanied by unavoidable tissue trauma such as breast plastics or abdominoperineal resections. We are now studying a controlled group of cases which tend to prove that this addition to routine surgical procedure will definitely cut the incidence of sepsis. These observations will be incorporated in a later report.

#### HAND INFECTIONS

Our various sulfonamide mixtures were employed in the treatment of a large group of hand infections.

As a rule the powder mixtures were applied with a blower to a surface moistened with hydrogen peroxide after proper drainage of underlying infections had been established. Pastes combining these agents were also used. Where a drain or drain pack is indicated, a strip of the "Nu-gauze" impregnated with an oily suspension containing sulfanilamide and sulfathiazole in either hydrogenated cocoanut oil or triacetin, and activated with minute amounts of compound solution of iodine, azochloramid, benzoyl peroxide or zinc peroxide is suggested. In any case, the dressing is fol-

lowed by delayed soaks, the medication being allowed to remain *in situ*.

This use of "delayed soaks" is a general principle which we offer for acceptance. To be fully effective, the local application of the sulfonamides or sulfonamide-oxidizing mixtures to all wounds associated with inflammation and cellulitis should be exposed to the beneficial effects of moisture and heat. By allowing four to six hours to elapse, the involved tissues have had an opportunity to absorb directly a certain amount of the chemotherapeutic agents and by this time moisture and heat will not only be of nonspecific help but will aid the further local absorption of the excess of the sulfonamide mixture.

We have found it practical to leave a sulfonamide dressing undisturbed for from four to five days and thereafter to dress it at intervals of five to seven days, cleaning the wound thoroughly with hydrogen peroxide, replacing the paste or powder and following this by immobilization. The need for frequent dressing is eliminated by this method, and, as Iselin<sup>37</sup> pointed out, too frequent dressings are one of the chief causes of chronicity in this type of lesion.

*Anterior closed space infections* were treated with the "fish mouth" or "hockey stick" incision. This group was found to fare better when dressed with pads and strips of moistened impregnated gauze (oily) than with dry powder. It became obvious that in small areas of infection where possible drainage obstruction was present, the dry powders are contraindicated unless accompanied by intermittent soaking.

*Flexor sheath infections* required more frequent dressing than the other types, although daily dressings are not indicated. In this group we have to deal more often with the problem of necrotic tissues which offer an abundance of peptone and peptone-like bodies which have been shown inhibitory to sulfonamide action.

*Osteomyelitis of the Terminal Phalanx.* We prefer Kanavel's<sup>38</sup> active technic in

contrast to Knapp's<sup>39</sup> "wait and see" method. The distal two-thirds of the phalanx is resected after the periosteum has been pushed down to the lower third. The wound is then filled with a thin paste containing the sulfonamide and oxidizing agent before removal of the tourniquet and is not disturbed for six to seven days unless temperature and pain warrant an earlier inspection. As a rule, pain and temperature will subside within forty-eight hours.

We have operated upon fifteen patients with osteomyelitis of the terminal phalanx in which the primary incision or, as we have found in many cases, incisions, were made by others. In none of these cases, had any type of sulfonamide mixture been used previous to the secondary operation. In contrast, no complicating osteomyelitis of the terminal phalanx or other extension of infection has occurred in the group which we treated early with sulfonamide-oxidizing agent mixtures. The oft tendered criticism that simple incisions might have produced similar results may be a just one. It is true that many paronychias, eponychias, subepithelial and subungual abscesses could be cured quite simply by the proper incision and drainage. We are of the impression, however, that the use of sulfonamides plus oxidizing agents locally, followed by "delayed" hot soaks, have a definite place in the treatment of all hand infections. While progression of the simpler types to more grave forms may not be common, any treatment which may hasten the end of the infection should be considered worth while.

#### HUMAN BITE INFECTIONS (MORSUS HUMANUS)

We doubt if any single type of wound requires more diligence and more exacting treatment than those of this group. Koch,<sup>40</sup> barely ten years ago, presented the first insight into this problem as a surgical entity and clearly demonstrated the anatomical considerations. In two recent reports, the results were far from favorable: Welch<sup>41</sup> reported six amputations and five

secondary operations out of his series of eighteen cases. He believes that a 33 per cent morbidity (flail or stiff joint) may be anticipated. The other series, reported by Boland,<sup>42</sup> records a similarly high incidence of amputations as well as several deaths. R. L. Maier<sup>57</sup> reported seventeen cases. He pointed out the importance of exploration of lesions over the knuckle in the flexed position. His results using salvarsan locally were excellent in early cases. There were four amputations in the late cases. More recently, he has used sulfanilamide locally but believes proper débridement to be of paramount importance. In this we concur.

It is important not only for the patient to seek immediate attention following this type of injury, but it is just as important for the physician accepting the responsibility to realize the septic nature of the injury with which he is dealing and the need for prompt attention. Regardless of the appearance of the wound itself, when the patient presents the history of having received it through the agency of human teeth, it becomes necessary to excise the adjacent tissues for at least one-eighth of an inch beyond the wound's border. The débridement, if the wound is situated in the region of the metacarpal head, is best done with the closed hand. This is the position in which the injury is, as a rule, sustained. Thus if the extensor tendon has been involved, it would, in the extended position, slide out of view.

It is advisable to flush out the wound with hydrogen peroxide and pack it with a mixture of sulfanilamide and sulfathiazole powders activated with either iodine compound solution in triacetin, 1:5,000, azochloramid in triacetin, 1:500, or zinc peroxide powder. The latter seems most effective.

We have treated eleven patients in this series. The earliest was seen fifteen minutes after the injury and the latest not until six days had elapsed. We believe that regardless of the intervening time and the nature of the wound presented, treatment is basically the same. It frequently becomes

necessary to sacrifice areas about the metacarpal-phalangeal joint as well as tendon. In our present experience, this group of human bite infections has not necessitated a single amputation. We may cite a case in point which has several interesting side-lights:

A white male, aged forty-four, struck his opponent in the mouth, sustaining a jagged laceration over the middle metacarpal phalangeal joint on the dorsal surface. It was six days before he sought medical aid. It is of passing interest to note the reason for this delay; it was due to a newspaper announcement that the police were searching for a man with this type of wound in connection with the murder of a woman. Not until the real culprit was apprehended did this patient present himself for treatment, six days after the injury.

The wound, one inch in length, extended obliquely over the joint. It exuded a profuse foul smelling discharge. The middle extensor tendon was apparently involved; the entire dorsum of the hand and middle finger showed marked swelling and dusky redness.

An elliptical excision of all tissue with extension for drainage up the dorsum of the hand was made. The extensor tendon itself was débrided only in part but was finally excised completely when found impossible to salvage.

Treatment consisted in flushing the wound thoroughly with hydrogen peroxide and packing it with a powder composed of equal parts of sulfanilamide and sulfathiazole with one-fourth part of zinc peroxide to supply the desirable oxidation environment. The wound was then overlaid with a medicated dressing containing sulfanilamide-sulfathiazole-azochloramid paste. At the beginning of the treatment lymphangitis, axillary adenitis and general constitutional symptoms were present. Improvement was continuous; the surrounding inflammatory reaction subsided, axillary gland involvement disappeared and suppuration was under control after six days. This therapy was continued until epithelialization on the granulating base was noted. Photographs were taken at the time of the excision and again with the final result. (Figs. 3, 4 and 5.) At the end of treatment there was only a limited (10 degree) impairment of full extension of the middle digit.

In five human bite infections seen within six hours, the method selected consisted of excision of the wound and packing with one of the above fortified sulfonamides followed by delayed intermittent saline soaks. In these no suppuration occurred. This group of wounds progressed to granulation and epithelialization without complication. In one case first seen eighteen hours after injury the wound edges were agglutinated, releasing foul smelling thin pus on separation. This wound was over the fifth metacarpal-phalangeal joint. Débridement included part of the capsule of the joint and an incision to evacuate the dorsal space. Recovery in this instance was completely satisfactory except for a slight defect in motion of the fifth finger.

Cultures and smears were made from these lesions. Blood broth agar yielded, for the most part, *Staphylococcus aureus* as a secondary organism to the streptococcus and Vincent's organisms noted on smears. The same technic was followed in the group seen late, but adequate drainage was provided. There were no deaths and no amputations. We shall report upon this subject more fully at a later date.

It should be further stated that in our group we withheld sulfanilamide therapy by mouth, thus giving us a rather definite means of determining the effectiveness locally of these compounds. However, it is advisable to use oral sulfonamides in cases of this type as an adjunct.

Radical, immediate treatment is indicated for wounds caused by the human bite. In every case the wound edges should be excised for at least a distance of one-eighth of an inch. The wound then is to be thoroughly flushed with hydrogen peroxide, followed by the local application of the activated sulfonamide mixture. In additional cases of this type of lesion, we have used several of many activating agents (oxidizing agents) such as potassium permanganate, iodine, zinc peroxide, azochloramid, etc. Our preference in this group is for the zinc peroxide-sulfonamide compound. The preparation should be

placed generously in contact with all surfaces and depths of the wound. As already stated, it is advisable to delay any soak

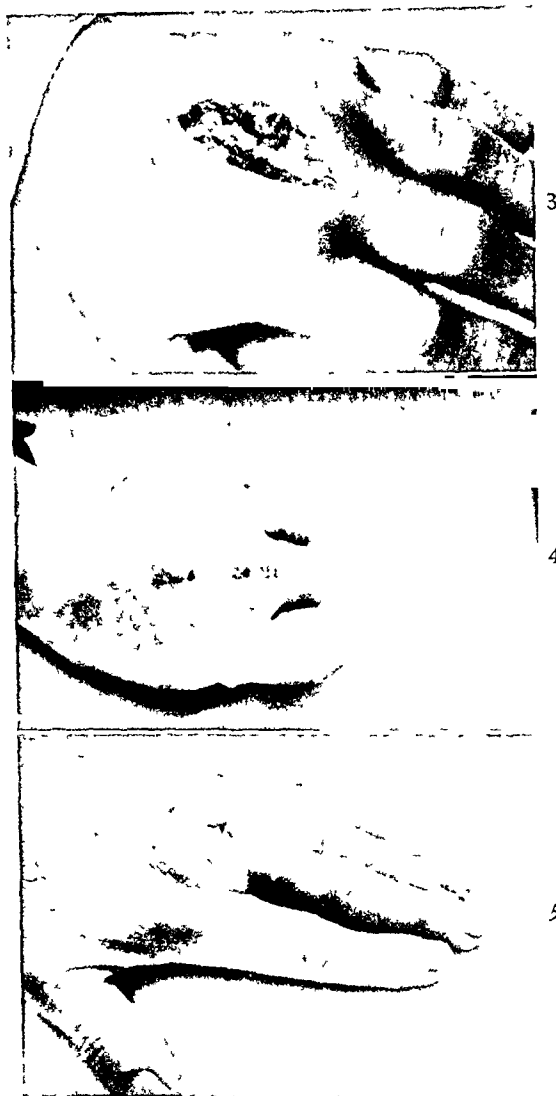


FIG. 3. Human bite infection as it appeared following preliminary excision and topical application of the No. 15 sulfonamide mixture.

FIG. 4. Human bite infection (Figure 3); end result showing unlimited flexion.

FIG. 5. Human bite infection (Figure 3); end result showing almost complete extension.

for six hours to allow local concentration of the sulfonamides in the tissues. Soaks may then be intermittently instituted every four hours, using normal saline.

We offer as contrasting controls for this group the reports of Welch<sup>41</sup> and Boland.<sup>42</sup> We believe the value of the potentiated sulfonamides has been clearly demonstrated when on several occasions in which

nonactivated sulfonamide was used, regression of healing occurred and we were forced to return to the activated form.

#### ABSCESS CAVITIES

A number of abscess cavities came under treatment, some without local medication, others with the usual run of antiseptics and still others with the sulfonamides, both activated with an oxidant and nonactivated. There can be little doubt about the increased efficacy *in vivo* of the activated sulfonamides in this group. Powders and pastes were used, also impregnated oily pack drains. The choice was largely on an anatomical basis, depending upon the size, configuration and position of the abscess cavity. The repeated observation of prompt cessation of suppuration, diminution of swelling and subsidence of surrounding inflammation with rapid granulation and healing was in itself so marked as to leave little doubt as to the superiority of this means of therapy.

The various types of abscesses need little discussion. The use of a sulfonamide intraperitoneally in the treatment of abscess or peritonitis of appendiceal origin has been reported by Mueller,<sup>24</sup> Ravdin et al.<sup>43</sup> and others. The placing of sulfonamide crystals or powder, previously heat sterilized, in the peritoneal cavity has become a more or less common practice in this type of case. In a few instances we have used 5 Gr. of sulfathiazole, activated with 0.2 Gr. of buffered azochloramid powder in abscesses of appendiceal origin. The abdominal layers were thoroughly flushed with a solution of the same mixture and closed with drainage. At present, for intraperitoneal application we advise the use of sulfanilamide and sulfathiazole powder or crystals in a 2:1 proportion. In general the potentiating agents thus far at our disposal are not recommended for intraperitoneal use. Further work in this field is being done.

In the ubiquitous suppurative sebaceous cyst in which dissection of the entire sac is impossible, we have repeatedly observed prompt subsidence of suppuration. The

significant findings in these lesions were lack of induration and freedom from chronicity. Healing has been about as prompt as in the simple subcutaneous abscess. Recurrence and recrudescence of infection have been minimized by the effective sterilizing action on any remaining fragments of the sac wall. As a rule, the cavity has been filled with either a sulfonamide paste or powder. A small impregnated gauze wick, which is removed at the end of twenty-four hours, provides additional medication and drainage in the early stage of treatment.

#### CARBUNCLES

We have employed but two surgical procedures in this group. The undermined cruciate incision has been used in the less extensive and smaller lesions; excision has been reserved for the more extensive and late cases. More effective and prompt control of the surrounding inflammatory zone has been observed with the fortified sulfonamides than with any other type of medication. Again, the choice of powder, paste or impregnated gauze depended upon the characteristics of the individual lesion. Impregnated gauze covered with impervious dressings has a definite place in the larger lesions. Complete filling with the powder was accomplished by means of an insufflator. Absorption of the sulfonamide was demonstrated by serum determinations. This was found to be more rapid and sustained in the powder groups. Caution is, therefore, suggested if a sulfonamide is also administered orally at the same time.

#### BURNS

We are concerned here only with the local therapy and assume of course that the treatment of shock, fluid loss and protein concentration have received ample attention whenever required. The total area of a burn is an important consideration in treatment. That the sulfonamides locally applied to burned areas are readily absorbed into the circulation has been

demonstrated by blood level determinations. In one of our cases, cyanosis, anorexia and nausea were attributed to the absorbed sulfonamides; Hooker and Lam<sup>44</sup> have mentioned toxic phenomena in two cases in which large amounts of the sulfonamides were used. We have employed powdered sulfanilamide or sulfonamide mixtures plus oxidizing agents as well as gauze squares impregnated with these medications. We have also applied by spray an emulsion containing 2 per cent sulfanilamide and 1 per cent sulfathiazole combined with 0.5 per cent zinc peroxide, using gentian violet-acriflavine solution as a vehicle. In the smaller burns the sulfonamide-zinc peroxide powder was dusted over the area, producing an eschar-like surface. These were covered with a parawax mesh dressing. Larger burns were sprayed with an atomizer, using the emulsion mentioned above, or covered with a water-soluble jelly containing the same ingredients. Pickrell<sup>45</sup> has recently reported the use of a 3 per cent sulfadiazine mixture in triethanolamine. Feinstone et al.<sup>46</sup> have recently summarized their experimental and clinical experience with sulfadiazine. Evaluation of its effectiveness locally requires further study. Our impression thus far indicates its superiority in oral therapy only. We did not encounter a secondary infection in any burn cases treated with the oxygen-potentiated sulfonamide mixtures.

Our series of burns, however, is small and further investigation is necessary. It is safe to state, nevertheless, that caution as to total dosage should be observed and that the potentiated sulfonamides offer, in this type of infection, as well as in the other lesions mentioned, a rather promising form of treatment. No more than 8 Gr. should be used in any twenty-four hour period, proportionately less for children. Cumulative absorptions should be borne in mind until the eschar-like crusts have become more firm.

Studies on various types of impregnated sulfonamide gauzes are being followed, as

we believe this to be the best type of secondary dressings in burn cases, as well as the most satisfactory emergency dressing in which local sulfonamides are to be continued as the eventual treatment. The gentian violet and activated sulfonamide jelly offers an easily applied primary dressing.

#### LEG ULCERS

The subject of leg ulcer is familiar to any surgeon who has attended surgical clinics for any length of time. It is quite beyond the scope of this paper to delve into the many problems associated with this lesion. We do not mean to disregard the various factors which at all times should be given axiomatic consideration, such as the state of the peripheral vascular system, constitutional disease, syphilis, diabetes, anemia, etc. For the purpose of this study we are concerned primarily with the problem of infection and assume that the other necessary treatments have received proper attention. In spite of all these general and local measures we have seen every conceivable type of mixture applied topically and have at some time or other in the past used most if not all of them ourselves. Our culture study from this group of wounds has indicated that *Staphylococcus aureus* and *albus* are the most predominant organisms but in many cases cultures have shown both *streptococcus* and *staphylococcus*.

We are forcibly struck with the persistent efficacy of the sulfonamides when applied to these wounds. In our first study, we powdered the wound surface with sulfanilamide crystals. We later combined sulfanilamide with sulfathiazole in equal parts; but the most effective means of therapy again was found to be a fortified mixture containing sulfathiazole and sulfanilamide with an oxidizing agent, for example, compound iodine solution 1:5,000 in triacetin or azochloramid in olive oil, 1:2,000; or zinc peroxide, 1:2,000 in sesame oil, cod liver oil or cocoanut oil. With this latter group we were able to control



quickly the superficial suppuration and were quite impressed with the repeated production of a clean, healthy, red granulating base which in many cases allowed the epithelial edges to close in rapidly.

We do not mean to infer that every leg ulcer can be completely healed by the simple application of one of these mixtures. Only too often we have brought the lesions to a standstill beyond which further progress was not evident. To complete healing it has sometimes been necessary to employ medicated boots, elastikon strapings, and in some instances vein injections, ligations and pinch grafts.

Nevertheless, many leg ulcers have been healed which had been previously treated by other means for periods ranging from six months to four years. Here, too, the effectiveness of local medication was increased by the simultaneous use of a sulfonamide compound and an agent of oxidizing properties.

The cellulitis and edema associated with infected ulcers first invited a choice between the use of elevation and hot wet massive dressings or soaks, and the use of the local sulfonamides. An extremely satisfactory and effective method was found in the following routine:

1. Adequate drainage of pockets when necessary.
2. Gentle débridement of wound.
3. Removal with ether of any oil or grease-containing medication previously applied.
4. Application of an activated sulfanilamide mixture directly to all parts of the wound by free swabbing or by insufflation.
5. Covering of the wound with gauze impregnated with sulfanilamide mixture.
6. Application of impervious perforated squares of cellophane or cilkaloid over the medicated dressing.
7. Bulky dressings for ample covering of wound and surrounding area.
8. Rest and dry heat to the part for six to eight hours, followed by:
9. Intermittent hot wet applications of normal saline every three to four hours.
10. Dressing changes at forty-eight to seventy-two-hour intervals.

11. This process is repeated, gradually lengthening the intervals between dressings and the number of wet applications as indicated by the progress of the wound.

12. When cellulitis and edema have subsided and the wound surface shows a healthy granulating base, pinch graft or a Thiersch graft may be attempted if the size of the lesion warrants it.

Small ulcerations may be dressed at weekly intervals with sulfonamide mixtures, preferably in the form of paste or ointment. By this method the beneficial effects of moisture and heat are maintained and the fortified sulfonamide is allowed to reach a beginning rise in the absorption curve so that local tissues have some degree of sulfonamide saturation before wet dressings are begun. The moistening of the dressings with normal saline further facilitates the local absorption of the sulfonamide at the time and prevents caking or crusting. Residual sulfonamide powders might be seen on many wounds after intermittent soaks without a change of dressing.

#### MISCELLANEOUS SURGICAL INFECTIONS

The sulfonamide-oxidizing agent mixtures have been utilized in the treatment of a heterogeneous group of cases covering many other types of lesions. Although no statistics are available, our findings have indicated this to be the most effective means of local therapy at our disposal at present.

It was found practical to apply the same principles to other fields of surgery. Thus in gynecologic lesions we obtained successful results in the treatment of vaginal and cervical infections, both of bacterial and trichomonas origin. Three modes of medication were found to be successful. Insufflation of a powder containing sulfanilamide and sulfathiazole plus zinc peroxide, use of impregnated cotton vaginal tampons, and vaginal suppositories containing sulfanilamide, sulfathiazole and zinc peroxide in a cocoa-butter base were

each found to be more effective than other methods used previously.

Excellent results were obtained in eleven cases of marked vaginal discharge with associated severe pruritus. In six of these the presence of the trichomonas was readily confirmed by examination of the saline smear. A routine was established for this type of case. All douches were prohibited. The vaginal canal and vulvar area were carefully cleansed with hydrogen peroxide, then thoroughly insufflated with the powder. Vulvar skin was then covered with an application of 2 per cent fuchsin or gentian violet-acriflavine solution and again insufflated with the powder while the dye was drying. Involved skin areas were then painted with collodion, which were allowed to dry. This was repeated twice weekly and in the interval the patients' instructions included the insertion of a sulfonamide-zinc peroxide suppository nightly or every other night before retiring. The results were exceptionally satisfactory, and particularly gratifying to the patients who had previously had little, if any, relief from itching and discharge. The prompt and consistent disappearance of the trichomonas in these cases was particularly noteworthy.

The same technic, omitting the skin treatment, has been found very effective in the postoperative management of cervical conizations, cauterizations and vaginal plastic procedures.

A colleague in the field of *otolaryngology* has reported encouraging results in otitis media with the potentiated powder mixture.

Although the successful use of sulfanilamide has been reported in the treatment of compound fractures by many observers, we believe that their results can be further enhanced by utilization of these newer combinations.

Similarly, in *orthopedic* and *traumatic surgery* with particular reference to war wounds, the satisfactory results obtained by the use of the Orr-Trueta technic as applied to bony and soft tissue injuries may be considerably increased by substituting gauze packing impregnated with

a potentiated sulfonamide for the ordinary vaseline gauze.

For similar reasons we advocate the use of enemas of sulfanilamide and sulfathiazole with potassium permanganate in the treatment of suppurative, ulcerative and otherwise infectious lesions of the colon and rectum.

A variety of cutaneous infections were treated with the sulfonamide preparations. They were particularly efficacious in several instances of extensive pyoderma. Impetigo and furunculosis responded favorably to dusting with the zinc peroxide activated powder supplemented by the ointment form. Several cases of resistant fungus infection (epidermophytosis interdigitale) were promptly controlled by a powder consisting of sulfanilamide, sulfathiazole and benzoyl peroxide. It is very likely that the activation of the fungicidal properties of the sulfonamides is further aided by the reduction product, benzoic acid, which exhibits a desquamating effect.

#### IDIOSYNCRASY

In the many thousands of dressings in which the sulfonamides were used, we encountered but three definite instances of idiosyncrasy to the drugs. One was the case of a male, twenty-six years of age, who had suffered an avulsed wound of the anterior portion of his leg. Shortly after the first application of sulfanilamide powder, an angry, red raised area developed about the wound and spread to the surrounding tissues accompanied by a diffuse papular rash. Under wet dressings with boric acid solution this subsided. Repetition of the application of the sulfanilamide caused a recrudescence of the local irritation and a recurrence of the rash.

Another case was that of a man, fifty-six years of age, with leg ulcers of long standing and an old thrombophlebitis on the same leg.

The third instance was the most bizarre and probably exemplifies an acquired sensitivity. It occurred in a fifty-two year old male who had been treated for an acute suppurative olecranon bursitis. After three

weeks of treatment the patient was well enough to be discharged. Two weeks later, however, there was an apparent recurrence

symptoms were absent, the rash was subsiding and the urinary sugar was negative. (Figs. 6 and 7.)



FIG. 6. Idiosyncrasy to topical application of sulfonamides for left suppurative olecranon bursitis. Note edema and discoloration about lesion and forearm with disseminated papulopustular eruption over face, trunk and extremities.



FIG. 7. Eight days following removal of all contact with sulfonamide. Edema and discoloration have subsided and the eruption is fading. Note also general improvement in appearance.

and the same sulfonamide preparation was used. In twenty-four hours there was a widespread moist eczema about the involved elbow, surrounded by diffuse papular lesions. The sulfonamide was again used locally and within the following twenty-four hours a generalized papulopustular rash developed over the entire body. This was accompanied by severe weakness, anorexia, nausea and temperature. The white cell count was 20,800 and the urine showed 3.0 per cent sugar. Saline baths were instituted and, as all contact with the sulfonamides was removed, improvement immediately followed. Three days later, the constitutional

We believe that, except in rare instances, no irritation is produced by the local application of the sulfonamides.

#### LABORATORY DATA

*Wound Flora.* A series of 100 consecutive, unselected wounds was studied. The following table indicates the incidence of organisms encountered:

	Per Cent
Staphylococcus pyogenes aureus . . .	48
Staphylococcus pyogenes albus. . . . .	32
Streptococci. . . . .	9
Diplococci . . . . .	6
Bacillus coli . . . . .	3
Bacillus pyogenes . . . . .	2

No attempt at a differential classification of these organisms was made. This table has little significance except that it

our confirmed impression that the mixture is much superior to either sulfonamide alone in local therapy.

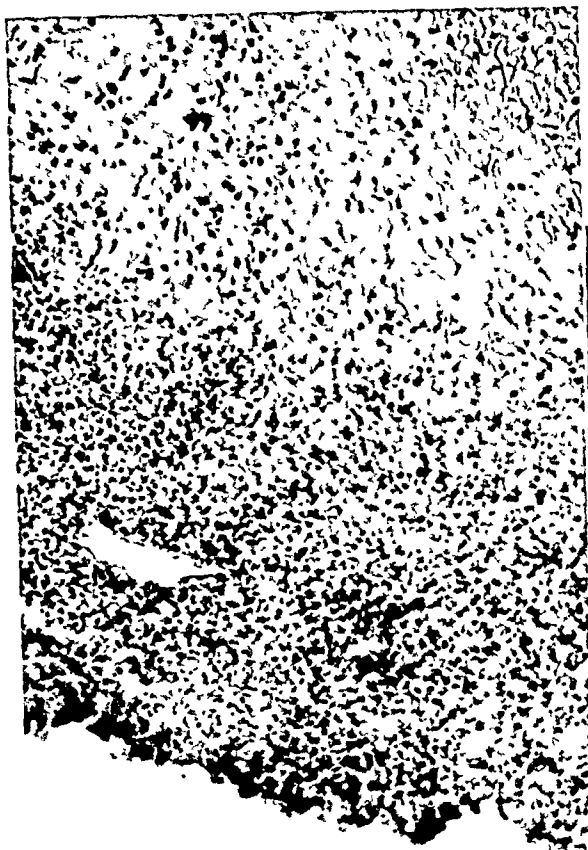


FIG. 8. Photomicrograph of coagulum removed from sulfonamide treated wound surface. The bottom of the photograph represents that part in direct contact with the wound surface. Note the highly cellular nature of this section made up of many fibrocytes, lymphocytes and occasional giant cell. The cellular invasion extends well up into the sulfonamide mass. In the right hand corner are spaces in which sulfonamide crystals were present. Studies of many sections of this type indicate that the sulfonamides offer no real inhibition to wound healing



FIG. 9. Appearance of wound coagulum from which section (Fig. 8) was made. Lesion was a suppurating ulcer on middle third of leg associated with an acute extensive cellulitis

indicates a general cross-section of the types of infection encountered in this study. It does stress, however, the importance of the staphylococcus as a predominant organism. While sulfanilamide serves as a more or less effective barrier against the ever present potential flare-up of streptococcic origin, we are here reminded of the desirable antistaphylococcic properties of sulfathiazole and the reason for using the combined sulfonamides. It is

#### STUDY OF SURFACE COAGULUM

We early noted the frequent appearance of a coagulum on the surface of wounds treated with the various types of sulfonamide preparations. This interested us considerably because of its possible bearing upon sulfonamide absorption and upon wound healing.

The type of coagulum varied from the dry crust seen on abrasions to an adherent pseudomembrane which covered the deeper

lymph-rich wounds from edge to edge. The coagula were removed and placed in formalin for later inspection. Cytological and bacteriological studies were made to determine, if possible, the presence of foreign body reaction, bactericidal, phagocytic or other characteristics. A photomicrograph of a typical sulfonamide wound coagulum is seen in Figure 8. Photograph of wound from which this coagulum was removed is illustrated by Figure 9. We found evidence of slight foreign body reaction and occasional giant cell formation. Sections stained for bacteria indicated some degree of phagocytosis and a definite diminution in the number of bacteria as compared with coagula or membranes removed from wounds treated with some more or less inert paste, such as boric acid ointment, which in some cases may leave a similar coagulum.

#### EFFECT OF SULFONAMIDE-OXIDANTS UPON STAPHYLOCOCCUS AUREUS IN VITRO

The inhibitory effects of sulfanilamide and sulfathiazole, singly and in combination, are tabulated below. Also are included

#### COMPARISON OF EFFECTIVENESS OF SULFONAMIDES, ACTIVATING AND NONACTIVATING AGENTS AGAINST STAPHYLOCOCCUS AUREUS

Broth Media .1 cc. inoculum (24-hour culture)	Clouding		
	24 hrs.	48 hrs.	72 hrs.
(A) Sulfanilamide 1:10,000.....	-+	++	++
(B) Sulfathiazole 1:10,000.....	-+	++	++
(C) Sulfanilamide plus sulfathiazole, 1:10,000.....	--	-+	++
Merthiolate 1:50,000.....	++	++	++
Merthiolate plus sulfonamide A.....	++	-+	++
Merthiolate plus sulfonamide B.....	+-	-+	++
Merthiolate plus sulfonamide C.....	--	++	++
Mercurochrome 1:50,000.....	++	++	++
Mercurochrome plus sulfonamide A....	+-	++	++
Mercurochrome plus sulfonamide B....	-+	++	++
Mercurochrome plus sulfonamide C....	-+	-+	++
Lugol's solution 1:50,000.....	++	++	++
Lugol's solution plus sulfonamide A....	--	-+	-+
Lugol's solution plus sulfonamide B....	--	--	+-
Lugol's solution plus sulfonamide C....	--	--	--
Azochloramid 1:50,000.....	++	++	++
Azochloramid plus sulfonamide A.....	--	--	++
Azochloramid plus sulfonamide B.....	--	--	-+
Azochloramid plus sulfonamide C.....	--	--	--

the effects of two nonoxidizing antiseptics (merthiolate and mercurochrome) alone and in combination with the sulfonamides compared with a similar series involving two oxidizing antiseptics (azochloramid and Lugol's iodine solution).

#### EFFECT OF ACTIVATED SULFONAMIDES ON OTHER UNICELLULAR ORGANISMS

The effects of the sulfonamides on ameba, paramecia, trichomonas and spermatozoa were observed. Here again it is possible to show that two more or less ineffective dilutions (sulfonamides and oxidizing agents) form together a very effective antibiotic agent. The arrest of the motility of these larger single celled organisms is a striking demonstration of the principle which we have applied in surgical practice.

The significance of this observation should not be overlooked or passed on lightly merely as an interesting observation. It gives much credence to our theory of mode of action, and in our opinion tends to place the phagocytic factor, so strongly suggested and developed by the many excellent experiments of Long and Bliss<sup>47</sup> and others, in a secondary position. These same investigators had earlier concluded that sulfanilamide must act on the micro-organisms and not on the leukocytes; later they reinterpreted their observation.

#### SULFONAMIDE PREPARATIONS EMPLOYED

While more than 100 preparations have been used in the treatment of patients during this study, it is considered quite impractical and unnecessary to list them all. Included below are the formulas of various preparations which gave excellent results in the types of wounds indicating their use. (By referring to the table of wounds treated, the most suitable preparation for each category may be determined.)

It will be noted that most of the preparations contain, in addition to their sulfonamide content, an oxidizing agent. Because some of these combinations may

not possess prolonged stability, the oxidizing component is preferably added just prior to use.

**Dried Crystals and Powder.** In this group the sulfanilamide crystals were used directly on infected wound surfaces and in cavities, with a powder blower. The sterile gauze pad applied directly to the wound was also given a coating of powder to reinforce the insufflated material.

**No. 15.**

Sulfanilamide.....	4 parts
Sulfathiazole.....	2 parts
Zinc peroxide.....	1 to 2 parts

**No. 16.**

Sulfanilamide.....	2 parts
Sulfathiazole.....	2 parts
Iodoform.....	$\frac{3}{10}$ part

**No. 17.**

Sulfanilamide.....	2 parts
Sulfathiazole.....	2 parts
Benzoyl peroxide.....	1 part

**Solutions and Suspensions.** It is apparent that true solutions are of comparatively limited value due to the relative insolubility of the sulfonamides. The 1 per cent solution of sulfanilamide was soon discarded in the treatment of infected wounds but it was reserved for prophylactic wound irrigation.

Because aqueous solutions are limited to high and ineffective dilutions, they were replaced by liquid suspensions in higher concentration. Early, suspensions of sulfonamides—sulfanilamide, sulfathiazole and sulfadiazine—were used separately. Later, sulfanilamide and sulfathiazole were used together (for example, No. 26 solution).

**No. 2.**

Sulfanilamide and/or sulfathiazole....	10 Gm.
Azochloramid in triacetin.....	1:500 100 cc.

**No. 99.**

Sulfanilamide.....	10 Gm.
Sulfathiazole.....	6 Gm.
Potassium permanganate, 1:4000.....	1000 cc.

**No. 26.**

Sulfanilamide.....	0.8 Gm.
Sulfathiazole.....	0.6 Gm.
Lugol's iodine solution.....	2.0 cc.
Distilled water.....	q.s. 100 cc.

**No. 43.**

Sulfanilamide.....	20 Gm.
Sulfathiazole.....	10 Gm.
Sodium tetra-decyl sulfate.....	2 Gm.
Azochloramid in triacetin (1:500)....	100 cc.

**No. 83.**

Sulfanilamide.....	25 Gm.
Sulfathiazole.....	12.5 Gm.
Iodine stock solution ( $I_2 = 2.2$ gr. per cc.) (1 to 5,000).....	1 cc.
Glyceryl triacetate.....	250 cc.

**Ointments and Pastes.** In this group high concentrations of the sulfonamides are possible. Many experimental ointment bases were tried. These included petrolatum, lanolin, aquaphor, spermaceti, cocoa butter and vanishing cream in various combinations.

**No. 40.**

Sulfanilamide.....	10 Gm.
Sulfathiazole.....	5 Gm.
Zinc peroxide.....	2.5 Gm.
Lanolin, or one of several water soluble bases q.s.....	100 Gm.

**No. 48.**

Sulfanilamide.....	5 Gm.
Sulfathiazole.....	5 Gm.
Azochloramid in triacetin 1:500.....	10 Gm.
Balsam of Peru.....	20 Gm.
Lanolin q.s.....	100 Gm.

**No. 81.**

Sulfanilamide.....	50 Gm.
Azochloramid in triacetin.....	60 cc.

**No. 89.**

Sulfanilamide.....	4 Gm.
Sulfathiazole.....	2 Gm.
Zinc peroxide.....	1 Gm.
Gentian violet.....	1 Gm.
Acriflavine.....	0.1 Gm.
Water-soluble base (with wetting agent) q.s. 100 cc.	

**No. 90.**

Sulfanilamide.....	4 Gm.
Sulfathiazole.....	4 Gm.
Lugol's iodine.....	5 cc.
Na tetradecyl sulfate.....	2 cc.
Oil of lavender.....	5 drops
Glycerol triacetate.....	10 cc.
Balsam of Peru.....	10 Gm.
Lanolin q.s.....	100 Gm.

**Suppository.**

**No. 60.**

Sulfanilamide.....	1 Gm.
Sulfathiazole.....	1 Gm.
Zinc peroxide (special).....	$\frac{1}{2}$ Gm.
Na tetradecyl sulfate.....	0.2 cc.
Cocoa butter q.s.....	4 Gm.

**Impregnated Gauze.** Gauze preparations containing various concentrations of the formulas suggested have been found useful in the packing of infected cavities and for the dressing of infected wounds. Such impregnated gauzes are of practical importance, particularly in hospitals, dispen-

saries and out-patient departments as well as in industrial clinics in which a great number of dressings are to be done. Such gauze may be kept ready for use in suitable containers. In this way minimum time is required for the dressing. This subject is being investigated for fuller discussion at a later date.

#### MECHANISM OF SULFONAMIDE MEDICATION

Long has stated, "When we come to the consideration of how sulfanilamide and its derivatives bring about the inhibition of growth, we enter the realm of pure fancy." However, on the basis of the theory that bacteria, both anaerobes and aerobes, produced hydrogen peroxide in the presence of oxygen, and that if this hydrogen peroxide were, through the means of chemotherapy, allowed to accumulate, a condition of bacteriostasis would inevitably result. Various factors indicate that the sulfonamide drugs may operate in this fashion. Hydrogen peroxide is known to be highly depressant to bacterial metabolism. However, under normal *in vivo* conditions the catalase in the tissues, as well as that existing in some bacterial cells, prevents the accumulation of hydrogen peroxide by destroying it as fast as it is evolved. If we may assume that the sulfonamides act in limiting the effectiveness of catalase and thus promote the accumulation of bacteriostatic levels of hydrogen peroxide, we may also assume that the addition of oxygen to the system through the medium of an oxidizing agent promotes and augments the production rapidly by the bacterial cells of a product inimical to their own existence. Under these circumstances, hydrogen peroxide comes into its own as a very effective antiseptic agent. Many observers have recorded the existence of a lag period prior to the appearance of any bacteriostatic effect, even after the establishment of satisfactory sulfonamide blood levels. This tends to support the theory; the time lag may represent the period during which an effective level of hydrogen peroxide builds up. While it is

highly probable that other enzyme systems are also affected adversely, we submit catalase as a type example.

Some have advanced their belief that phagocytosis plays the primary rôle in sulfonamide therapy. We believe, however, that this element is of secondary importance, disposing of the bacterial cells in the usual manner after hydrogen peroxide has reduced their viability.

Levaditi<sup>48</sup> stated that sulfanilamide prevents the specialized metabolic activity required of invading organisms. "The evidence so far obtained indicates that this effect may be achieved through the prevention of the utilization of the protein substrate by the organisms." He, however, stated that he could not as yet accept it as fact that the chemotherapeutic compounds acted directly upon the micro-organisms, the reason being that he found that if the drug were injected directly into the peritoneum, where it should come into immediate contact with infectious agents, the therapeutic response was far less than when administration was by the subcutaneous or oral route. It, therefore, seemed to him that the drugs, sulfanilamide as well as the dye derivatives, must undergo a further change in the body to a substance which he termed the "active principle X" (quoted from Long and Bliss<sup>49</sup>). Since that was written (1937), the use of sulfanilamide in the human peritoneal cavity has been proved very effective.

Lockwood<sup>50</sup> advances a theory which is quite similar to Levaditi's in that he considers interference with the bacterial source of nitrogen to be part of sulfonamide activity.

Locke and Main, Shinn and Mellon<sup>51-54</sup> have advanced fascinating principles which attempt to explain the mode of action as follows: "The pneumococcus and the hemolytic streptococcus have the property of being able to produce hydrogen peroxide without, at the same time, being able to prevent peroxide accumulation." Both are sensitive to peroxide injury and depend for peroxide elimination on catalase, borrowed

from the medium supporting growth. Catalases decompose peroxide and permit growth as long as they remain efficient. These enzymes are activated by substances related to hydroxylamine in structural properties. They then write that "substances analagous to hydroxylamine are produced from sulfanilamide when dilute solutions of the drugs are exposed to ultra-violet radiation and they should be easily produced from sulfanilamide by peroxide-producing pneumo and streptococci through equivalent processes of oxidative disintegration producing an amount of anti-catalase within the multiplying organisms sufficient to permit the accumulation of the hydrogen peroxide to levels forcing changes in gross character."

The effects of sulfanilamide in the treatment of experimental streptococcic infections of mice led Long and Bliss<sup>55</sup> to believe that the action was primarily one of slowing down the rate of multiplication and thus permitting the phagocytes to dispose of the bacterial cells. Other investigators have divergent opinions in regard to this. Shaffer<sup>56</sup> believes that the oxidized derivatives of sulfanilamide have a high oxidizing intensity which damages the reducing system of the bacterial cells as well as human cells, but that the human organism is better able to withstand these various effects than are the bacteria.

Lockwood<sup>50</sup> in discussing the mechanism of action concludes that sulfanilamide induces a physicochemical alteration in the antigenic structure of hemolytic streptococci which decreases its invasive capacity or virulence, and that the bacteriostatic effect thus produced is probably the results of a specific interference with enzymatic utilization by the bacteria of some nutritive chemical factor such as para-aminobenzoic acid. As a corollary to our theory above, available evidence suggests the possibility of an additional avenue of attack. It is well known that paraminobenzoic acid in small amounts will inhibit the action of comparatively large amounts of sulfonamide. If the simultaneous contacting with

an oxidant facilitates oxidation of the paraminobenzoic acid—or the paraminobenzoic acid-like substances, it further enhances the sulfonamide action. Thus a two-fold purpose is theoretically served by the oxidant potentiated sulfonamide.

In going over the contributions of many investigators who have dealt with the subject of mechanism of action of the sulfonamides, we find that there are roughly two schools of thought, those who believe that phagocytosis plays an important or primary rôle and those who believe that the sulfonamide action is concerned more directly with the bacterial cell, and that phagocytosis is merely an expected sequel.

Our work has reached the point where we subscribe to the antienzyme theory. We believe that the action of sulfonamide is a direct one on enzyme systems depending for its effectiveness on factors of environment, and that the phagocytosis is a secondary phenomenon which plays its part in the usual fashion after bacteriostasis has been effected.

We have outlined above a mode of action based on our own chemical and laboratory findings as well as upon the contributions of many other investigators. We cannot stress too greatly the significance of our observations with regard to the activation or potentiation of the sulfonamides by oxidizing agents. We believe that not only does this offer an enhanced method of treatment, but it substantiates the anti-catalase theory and gives much credence to the observations upon which it is based.

#### COMMENT

The writer realizes only too well that his attempt to describe the experience of several years' work in a paper of this scope offers many difficulties in bridging the gap between multiple observations and unified concepts. Repetition in some places has been unavoidable for the sake of continuity and completeness.

However, several basic concepts arise from the welter of findings: *The most effective local antibacterial agent is a com-*



*combination of sulfanilamide and sulfathiazole rendered more effective by an oxidant.* Depending upon the nature of the wound or infection, a choice of powder, ointment, paste, jelly, solution or impregnated gauze can be prepared. The activating agents of choice vary with the vehicle. Thus for the powder form, zinc peroxide is favored; for ointment and paste, azochloramid and zinc peroxide are chosen; for solutions, iodine, azochloramid and potassium permanganate may be indicated.

Regardless of the form or content of the above medications, a local excess of the sulfonamides must be made constantly available for absorption by the tissues and to make up for that lost through other means. The addition of a wetting agent such as sodium tetradecyl sulfate will enhance the effectiveness of the suspensions and ointments.

The combination of sulfonamides, oxidizing agent and wetting agent is the key for the most effective local antibiotic mechanism. It has been shown that this form may vary from solution to suppository. It is obvious by now that the entire range of bacterial infections, in as much as they are concerned with surgery and its branches, must of necessity be reconsidered in the light of the new era of activated sulfonamide therapy.

The treatment of war wounds has been and will be still further modified as progress in this field of active chemotherapy continues. Every combatant should carry potentiated sulfonamide powder for immediate use. To wait until the patient reaches the evacuation or base hospital is to wait too long. A sharp decline in gas gangrene, amputations and in the complications subsequent to suppuration can be anticipated.

#### CONCLUSIONS

1. The sulfonamides have been shown to be effective by local application in the treatment of a wide variety of wounds and wound infections.

2. The combination of sulfanilamide

and sulfathiazole—in local use—is more effective than either one alone.

3. Wound healing is not appreciably inhibited by the presence of sulfonamide drugs.

4. The sulfonamides are absorbed from wounds into the general circulation. This has been demonstrated by serum determination.

5. Idiosyncrasy to local use is rarely encountered.

6. Local applications are effective in the form of solutions for irrigation, in wet dressings, powders, ointments, pastes, suspensions and medicated gauze depending upon the anatomical and pathological characteristics of the lesions.

7. Bacterial action is inhibited more completely by simultaneously contacting the bacteria with a sulfonamide compound while creating an oxidation environment at the point of contact.

8. The potentiation of the sulfonamides by this method is far greater than would be expected from a simple additive phenomenon.

9. This phenomenon of sulfonamide potentiation is not only antibacterial but it is antibiotic with regard to other unicellular organisms such as ameba, paramecia, trichomonads, spermatozoa and certain fungi.

10. Clinical and laboratory observations with the "potentiated" sulfonamides indicate that the mode of action of sulfonamide medication is a direct attack on the bacterial cells. An explanation for this mode of action has been described.

11. An extended field of investigation has been opened by the discovery of the principle of sulfonamide potentiation by means of oxidizing agents.

12. The ideal surgical antiseptic, harsh to bacteria and kind to tissue, has been approximated.

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FREQUENT dressings of wounds in connection with compound fractures are unnecessary. The patient should be splinted and dressed in such a way that he is not exposed to secondary and mixed infection by postoperative dressings, irrigations, or wet antiseptic packs.

From—"Wounds and Fractures"—by H. Winnett Orr (Charles C. Thomas).

# PILONIDAL CYSTS IN THE ARMY

A REPORT OF THIRTY CASES OCCURRING IN NINETY-SEVEN DAYS AT  
FORT SILL, OKLAHOMA

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## INTRODUCTION

**D**URING the months of August, September, November, and the first five days of December, 1941, thirty cases of pilonidal cyst were seen on the surgical service at the Station Hospital at Fort Sill, Oklahoma. Thus, one case was seen every 3.23 days.

Fort Sill is an Army post which had an average population of approximately 30,000 officers and enlisted men during this study. The calculation of the exact incidence was well nigh impossible due to the shifting nature of the population, but the approximate incidence was 0.1 per cent. The white, Negro and American Indian races were all represented in the population, and no cases were seen in the Indian and only one in the Negro race.

## DEFINITION

The term, "pilonidal cyst," is applied to a congenital cyst which is found external or posterior to the sacrum and coccyx. It is sometimes known as a pilonidal sinus or fistula, a sacrococcygeal dermoid or a sacrococcygeal cyst, a coccygeal fistula, a postanal dermoid or a postanal dimple. The term, "pilonidal," is derived from the Latin words "pilus," which means hair, and "nidus" which means nest. Pilonidal cysts are epithelial-lined sacs, usually with one or more cutaneous openings situated in the midline of the sacrococcygeal area.

## ETIOLOGY AND INCIDENCE

The etiology of pilonidal cysts has never been definitely settled. The condition was first described by Warren in 1867. He thought it was due to a reversed hair folli-

cle. In 1887, Tourneux and Herrmann advocated the theory that the cyst originates due to the persistence of coccygeal vestiges of the neural canal. If this theory is true, the possibility of causing a meningitis always exists when surgery is done in this region. From 1882 to 1886, Lannelongue advocated the theory that it is a process of ectodermal invagination due to faulty median skin agglutination of the sacrococcygeal region. Another interesting explanation of its etiology is advocated by Stone. He explains it from a standpoint of evolution and thinks that it is a vestigial structure analogous to the preen gland of birds.

There are very few satisfactory statistics covering the incidence of pilonidal cysts and one really does not have much of an idea as to how common it really is. Bellevue Hospital, in New York City, reports 288 cases on its surgical service in ten years. The University of Pennsylvania outpatient clinic had a percentage of 0.9 per cent. In a general hospital for veterans the percentage was quoted as 0.5 per cent. However, thirty cases occurring in ninety-seven days at the Army camp of Fort Sill suggests that it must occur more commonly than the above figures show, or that trauma plays a very common exciting factor. The patients in this series were all young, healthy, adult males who were engaged in vigorous activity such as any army camp demands.

It is interesting to note that pilonidal cysts occur in men three times as often as in women. It very rarely occurs in negroes and no cases have been reported in Mongolians or American Indians. The condition is not hereditary but several

cases occurring in the same family have been reported. It usually occurs in early adult life.

#### SYMPTOMS AND DIAGNOSIS

Most of our cases were seen in the acute stage. The patient was admitted with swelling and inflammation in the sacrococcygeal region. They complained of pain throughout the lower back region which would vary from a mild throb to severe pain which radiated down the thighs which made it very painful to walk or sit down. There was a discharge from the sinus which varied from a seropurulent discharge to frank pus. This discharge was very irritating to the surrounding skin and often caused a severe pruritus. This latter complaint we found most interesting and it stresses the importance of considering a pilonidal sinus in the differential diagnosis of "pruritus ani." There may be chills and fever.

Our patients who were chronic cases complained of a dull back ache, which was aggravated by exercise and recurrent abscess formation. The chronic cases were much longer in healing and these patients had more pain than those who complained of the condition for the first time. Thus, it is imperative to handle the case correctly from the start and to show the patient why surgery is needed.

The diagnosis of pilonidal sinus is relatively simple. However, it is often confused with other conditions occurring in the same area. The location of one to several sinus openings several inches above the rectum and in the midline in the sacrococcygeal region should suggest a pilonidal cyst. Often there is a hair protruding from these openings, and the opening will probe upward whereas a rectal fistula will probe downward and into the rectum. However, a sinus opening in this region should indicate a thorough history and proctoscopic examination before surgery is attempted. Various opaque dyes have been devised so that the cyst and its ramifications can be studied by x-ray.

#### DIFFERENTIAL DIAGNOSIS

The most common conditions which are confused with pilonidal cysts are osteomyelitis, tuberculosis or syphilis of the sacrum and coccyx. Thus, every case should have an x-ray of the sacrococcygeal vertebrae and a chest plate taken and a blood Wassermann test made. Also to be considered in the differential diagnosis are anal, or rectal fistulas, sebaceous cysts, pyogenic infections, lipomas, teratoma, fetal implantations, traumatic dermoid, implantation cysts, anthrax and actinomycosis.

#### PATHOLOGY

The specimens were very similar grossly and consisted in blocks of tissue measuring about 12 by 2 by 2 cm. There were from one to four sinus tracts leading into the main cystic sac which was often filled with silky hair or frank pus.

Histologically, the picture was essentially the same in all cases. The main tract consisted of granulation tissue rich in blood vessels and exudate of an acute or subacute nature with wandering cells usually predominant. Lying loosely in the stroma were numerous hairs surrounded by giant cells of the foreign body type. The hairs were devoid of sheaths. The cyst and the adventitious branches were lined with stratified squamous epithelium.

#### TREATMENT

The primary objective of any form of treatment is to cure the patient permanently in as short a time as possible. Thus, in treating pilonidal cysts the entire sinus and all of its ramifications must be completely excised so that the condition will not recur.

Several different technics have been developed for the relatively clean cases. They all require complete excision of the cyst and its ramifications but differ in whether the wound is packed open, or whether it is partially or completely closed. Various sclerosing technics have been described but none were used in this series.

Our cases were handled by excision and open packing.

Great care must be taken before excision to make sure that the primary infection has subsided. If the infection is mild, local hot packs are applied to the area until the inflammation has become quiescent. If an abscess is present, it is incised and drained.

Radical surgical excision *en masse* of the tract-bearing area including a wide zone of normal tissue will result in a cure in about 75 per cent of the cases. Primary closure without drainage failed to show any superiority to partial closure or open packing in a series of fifty-four cases reported by Silverman. Our method of wide excision and packing gives results comparable to those of Silverman's. However, not enough time has elapsed for an adequate follow-up in our series.

Our patients were fed a full diet up until the morning of the operation. Enemas were given the night before and the morning of the operation. Each patient was given  $1\frac{1}{2}$  gr. of a barbiturate the night before surgery and at 6 A.M. on the morning of the operation. Morphine gr.  $\frac{1}{4}$  and atropine gr.  $\frac{1}{150}$  were given just before surgery.

Spinal anesthesia was used exclusively in all but two cases, 100 mg. of novocaine being used in each case. We feel that there is little danger of carrying organisms into the spinal canal if the needle is inserted above the infected area after the skin over the area has been well cleansed. Local anesthesia seems contraindicated for three reasons: (1) The needle when passed through infected tissue into the surrounding normal tissue mechanically spreads the infection and necessitated wider excision; (2) novocaine as a local anesthetic neutralizes the sulfanilamide powder used in the wound postoperatively, and (3) the spinal anesthetic gives much greater relaxation in the area. This latter is essential to successful surgery because some of the ramifications of the sinus tract may be extensive.

The patient is placed prone on the table with the head and foot of the table lowered twenty degrees. The operative site is cleansed thoroughly with soap and water

and then painted with Scott's solution. All of the sinus openings are injected with methylene blue under moderate pressure using a blunt cannula. The approximate size of the cavity is estimated by the amount of methylene blue that is used.

Different operators disagree on the efficacy of methylene blue. We believe that it enabled us to remove more of the diseased area although it is not specific for diseased tissue. The dye will not always enter all of the sinuses. However, we believe that its use is a distinct aid.

Two elliptical incisions are made approximately one-half inch lateral to the most lateral sinus opening and carried through the skin, subcutaneous tissue and fat down to the fascia lining the coccyx and sacrum. Great care is taken not to enter the sinus cavity or to miss any of the infected tissue. This tissue is then removed as a block. If methylene blue is found on the fascia covering the coccyx and sacrum, the infected fascia is excised and the bone is curetted. At times it may be necessary to remove the coccyx.

All bleeding vessels are carefully ligated. Bleeding in the fascia overlying the coccyx and sacrum is best controlled by suturing, as ligatures often slip off when the patient moves about. It is essential to have a dry postoperative field because of the proximity of the wound to the rectum and of the excellent culture medium offered by blood.

Sulfanilamide powder is then dusted into the wound. It has been shown that the local use of this drug will give a concentration of 800 to 900 mg. in the surrounding tissue. The wound is then packed open with iodoform gauze and a sterile dry dressing is placed over the packing described. Adhesive tape is then applied tightly across the entire area to help prevent postoperative bleeding which did occur in two of our cases.

The patient is then placed prone in bed with the foot of the bed elevated for six hours. This was done to help prevent the postoperative headache which occasionally follows a spinal anesthetic. Codeine, aspirin and a barbiturate were used to control the

postoperative pain and restlessness. The patient is encouraged to sit by the side of the bed the morning following surgery and to walk to the latrine and about the ward. He is sent to the hospital mess on the third postoperative day and encouraged to take light exercise. No effort is made to constipate him and every effort is made to encourage the taking of exercise. One of our patients, who was a commissioned officer, took charge of the artillery firing on his fifth postoperative day.

The wound cavity is repacked firmly every third day with iodoform gauze, and the external dry dressing changed daily or as needed. Sulfanilamide powder is dusted into the wound cavity with each repacking and we believe that this played the major rôle in preventing postoperative infection. So far, none of our series has developed a postoperative infection. Occasionally 5 per cent silver nitrate is used to stimulate the growth of granulation tissue. The wound cavity heals in from eight to eleven weeks.

Block excision of the tract, with a transplanted pedicle flap to fill in the resultant cavity, has not seemed practical to us. The purpose of this operation is to place the scar lateral to the midline in order to prevent any tenderness from sitting on a tight, hard scar. None of our patients gave this complaint, and we believe that this operation just opens a new area for potential infection.

At this time we plan on giving a dipilatory dose of x-ray over the skin of the region postoperatively. This would serve to inhibit hair follicle activity to whatever extent this may be a cause of recurrence.

#### CONCLUSIONS

1. Thirty cases of pilonidal cysts occurring in ninety-seven days in a representative army camp are reported.
2. The high incidence of this entity in such surroundings indicates that trauma plays an important rôle in its etiology.
3. Spinal anesthesia was the anesthetic of choice.
4. Surgical procedure consisted in wide excision and open packing.

5. Sulfanilamide powder was used topically in all cases with no postoperative infection encountered.

6. Postoperative management consisted in getting the patient out of bed as quickly as possible. Normal bowel habits were encouraged.

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# RUPTURED UTERUS FOLLOWING THE SPINELLI OPERATION FOR INVERSION OF THE UTERUS\*

## CESAREAN HYSTERECTOMY: RECOVERY OF MOTHER AND BABY CASE REPORT

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**P**UERPERAL inversion of the uterus is a rare complication of pregnancy.

In a recently published table by Bland and Goldstein,<sup>1</sup> the range was from 1 in 10,000 to 1 in 400,000 cases, whilst the Leningrad Lying-In Hospital had reported 0 in 250,000 cases. Puerperal inversion of the uterus has not occurred in my hands, but, from 1924 to 1941, six women with this disorder have been referred to me for treatment. One was seen shortly after the accident, the placenta was removed and the uterus reinverted. Three were seen in the so-called chronic stage of the lesion, after involution had taken place, and were treated by the Spinelli operation, anterior colpohysterotomy. One woman had an abdominal panhysterectomy because of gangrene of the uterus and hemorrhage, and still another a vaginal hysterectomy for the same reasons. Since two of these six patients had hysterectomies, there remained four who could subsequently become pregnant, but it has been encountered in only one instance, this patient being among those who had previous Spinelli operations. Her case forms the basis of this report. (Case v.)

### CASE REPORT

Mrs. M. B., aged thirty, a secundipara, was admitted to the Carney Hospital on May 25, 1938. She had had two children, both delivered by forceps, the last infant having been born ten weeks before admission. For seven days preceding admission she had had a constant brownish discharge and hemorrhages, the hemorrhages

being especially severe when straining at stool. On admission an examination was made; the vagina was filled with blood clot, the equivalent of two handfuls. After the evacuation of the clots a puerperal inversion was discovered. On inspection the striking feature was the marked pallor. The hemoglobin was 45 per cent, the red cell count 2,770,000 and the white cell count 6,200. During the afternoon of May 26 she was given a blood transfusion by the citrate method, 500 cc. of blood being administered. She was operated upon on May 27, 1938, under spinal anesthesia, a typical Spinelli operation being performed. Drainage in the anterior and posterior cul-de-sacs was instituted. A second blood transfusion was started as soon as the patient was returned to bed. Again, the citrate method was used and 500 cc. of blood was given, a total of 1,000 cc. being administered. She stood the operation well. She had a mildly febrile convalescence. The temperature was 102°F., the pulse 130 and the respirations 34 on the first postoperative day, but all three had become normal by the tenth day. She was discharged from the hospital on June 11, 1938, seventeen days after admission, her condition then being entirely satisfactory.

On July 18, 1938, she was examined in the office, at which time the abdomen was soft, relaxed, tympanitic, and there were no masses or areas of tenderness. The perineum was relaxed, the cervix was healed, the uterus was normal in size, in second degree retroversion, and the adnexa were normal. The cervix, as seen through a speculum, showed good healing. The drainage areas, as well as the anterior vaginal incision, were healed, and there was no cystocele or rectocele. The blood picture was normal and the operative result entirely satisfactory.

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The patient next reported to the office on February 24, 1941. Her last menstrual period had occurred from July 9 to July 13, 1940. Her

showed no abnormal elements. A *cesarean section* was advised because of the previous long incision which extended from the fundus to the



FIG. 1. Photograph of anterior surface of uterus. The serosal surface is ragged and the long tags of edematous serosal and fibrous tissue are evident. In the upper portion there are two dark fusiform areas representing the points of rupture. The dark maternal surface of the placenta is just visible protruding slightly through these openings. In the lower right portion the area of recent surgical incision is seen. Through this gaping area the glistening fetal surface of the placenta is evident. The wide dark isthmus is present below.

confinement, by dates, was expected for April 15, 1941. Although advised to the contrary, at the time of her discharge from the hospital, she had had no prenatal care during this pregnancy. However, only for a mild trichomonas vaginalis infestation, for which treatment was prescribed, examination showed her to be in good physical condition. The pelvimetry revealed an ample pelvis, and all measurements to be within normal limits. The uterus was 32 cm. in height, measuring from the symphysis pubis; the fetus was well formed, and presented by the vertex in the left occipito-anterior position; the fetal heart tones, which were heard in the left lower quadrant of the abdomen, were of good quality and the rate was normal; the blood pressure was 134 systolic and 90 diastolic; and the urine



FIG. 2. Photograph of the opened uterus showing internal surface with attached placenta. The shining fetal surface, the bilobed character and the prominent vessels of the placenta are evident. The marginal attachment of the cord is seen in the upper portion. The thick myometrium is well shown in cross section on the left. The points of rupture, being covered by the placenta, are not visible in this view.

os externum of the cervix. She was instructed to report every two weeks for examination, but her next visit was made on March 17, 1941, three weeks later. The uterus was 38½ cm. above the symphysis; the fetus presented by the vertex in the left occipito-anterior position; the fetal heart tones were heard in the left lower quadrant, and were of good quality, and the maternal heart was normal. There were slight varicosities of the left leg but no edema. The urine was acid and showed no sugar and no albumen. The date of the cesarean section was set for March 31, 1941, in order to avoid the strain of the last two weeks of gestation on the uterine scar.

On March 28, 1941, she awoke in her home, twenty miles outside of Boston, at 6 A.M. but did not get out of bed. At 6:15 A.M. a sharp pain was experienced in the abdomen which was quickly referred to the right shoulder. She was seen by her family physician who immediately sent her to the Carney Hospital in an ambulance. Upon her admission to the hospital it was obvious that she had a ruptured uterus. She was in good condition, had but moderate shock and was directly prepared for a laparotomy.

*Operative Procedure:* Fifteen cc. of 1 per cent solution of neutral acriflavine in glycerine were instilled in the vagina. The urinary bladder was

catheterized. The abdominal cavity was entered through a median suprapubic incision, extending from the symphysis to the umbilicus.

the cervical canal. All pedicles and raw areas in the pelvis were covered over by peritoneum and the ovaries were suspended to the round



FIG. 3. A low magnification showing a transverse section through the wall of the uterus above and the attached placenta below. This section is taken in the line of medial scarring 3 to 4 cm. distal to the area of laceration. Along the upper surface of the uterus, abundant tags of scar tissue are easily recognizable. The v-shaped depression corresponds to the depression seen grossly on the surface of the uterus in the area of former incision. The apex of the v may be followed into the substance of the uterus leading to an area of scarring. This area is approximately one-third as thick as the myometrium elsewhere. There is actually much less muscle in this area. There is an artificial line of cleavage separating uterus from placenta. In the mid-zone between uterus and placenta the vessels are dilated, and one contains a recent thrombus.  $\times 5$ .

Considerable free blood was found in the peritoneal cavity. A few fine peritoneal and omental adhesions were ligated and resected from the posterior surface of the uterus. A longitudinal incision was made in the anterior wall of the uterus, and a male fetus, presenting by the vertex, and weighing 8 pounds, 10 ounces (3,933 Gr.) was delivered. The baby was resuscitated without difficulty. The uterus was turned out and inspected, and a rupture in the previous scar, about  $2\frac{1}{2}$  cm. in diameter was found at the fundus. There was a weak point in the scar about 8 cm. below the area of rupture, the rest of the scar having held together. The placenta was left *in situ*, and a supravaginal hysterectomy, with the conservation of the adnexa, was performed. A small cigarette drain was introduced in the vagina through



FIG. 4. A higher magnification showing a portion of Figure 3 comprising the serosa and myometrium in the area of scar formation. The thickened and ragged serosa is sharply demarcated from the underlying muscularis. A narrow line of scar tissue may be traced from the serosa into the substance of the uterus where it expands in a somewhat irregular area of scar formation.  $\times 13$ .

ligaments. A cigarette drain was placed in the posterior cul-de-sac and allowed to come out at the inferior angle of the incision. The sigmoid was brought down to roof over the pelvis. A large blood clot, extending from the liver to the pelvis, and filling the right gutter was removed, the liquid blood being left in the peritoneal cavity. The incision was closed in layers. The patient was returned to her bed in good condition, where she was given a blood transfusion of 500 cc. using the citrate method. At this time both mother and baby were doing well.

The specimen was submitted to Dr. H. E. MacMahon, Professor of Pathology at Tufts College Medical School, to whom I am indebted for the pathological report and photographs.

**Gross Description.** The specimen consisted of an enlarged edematous gravid uterus from which the infant had been removed. The uterus measured 18 cm. in length, 17 cm. in width and 8 cm. in thickness. It had been removed at the level of the isthmus where it measured roughly 6 cm. in width and 2 cm. in thickness. The canal here was lax and admitted the tips

of three fingers. The lumen in this area was approximately 3 cm. in diameter. The right side of the uterus was somewhat more dis-

opening, became transparent and paper-thin. The lateral margins of the uterus were represented by freshly dissected surfaces in which



FIG. 5. A still higher magnification showing a section of the myometrium seen in Figures 3 and 4. This is taken in the area of scarring. Several scattered muscle bundles composed of hypertrophied muscle fibers stand out conspicuously against a background of edematous connective tissue. In the very center of the field individual muscle fibers of a muscle bundle show atrophy and degeneration. There are areas of edematous scar tissue staining darkly in which collagen fibers show swelling, fragmentation, and an alteration in tinctorial reaction—findings consistent with autolysis.  $\times 131$ .

FIG. 6. A still higher magnification from the area of scarring of the myometrium seen in Figures 3, 4 and 5. In the center of the field individual muscle fibers show atrophy, degeneration, necrosis and infiltration with histiocytes. Phagocytosis of necrotic muscle is taking place. The adjacent collagen is swollen and at one or two points shows disintegration. Some of the nearby muscle fibers are large and well preserved. Others are small and atrophic.  $\times 200$ .

tended than the left. The serosal surface in the region of the fundus and along the anterior surface, especially in the region of the midline was ragged, and long membranous tags of edematous serosal and fibrous tissue could be picked up easily with the fingers.

The most striking gross lesion was the presence of two roughly fusiform and gaping openings in the midline in the region of the fundus and anterior surface of the uterus. Each of these openings measured roughly 3 cm. in length and 2 in width. Each was filled with the dark red granular surface of bare placenta. The placental tissue was unusually soft in this area and somewhat separated. These two perforations were separated by a thin and almost transparent strip of muscle and serosa which measured about 2 cm. in width. A probe could easily be passed from one perforation to the other. The placental tissue here was only loosely attached to the uterine wall. The margins of these tears were somewhat irregular and the uterus here, as it reached the actual

vessels, the stumps of tubes and round ligaments could be identified.

There was a recent surgical incision through the anterior wall of the uterus, 3 cm. in length. This began 2.5 cm. above the lower dissected surface in the midline, and extended somewhat obliquely upward and to the left. The wall of the uterus in this area of incision was lax, grayish pink and edematous and varied from 1.5 to 2 cm. in thickness. This opening gaped slightly, exposing a small segment of bare dark purple placenta. This was a portion of the maternal surface of the placenta facing the anterior wall. The membranes in this area were torn and were rolled up along the free edge. Approximately 2 cm. of cord projected through this surgical opening. It was possible to insert one's hand into the cavity of the uterus through this recent line of dissection. The sac was everywhere intact except in the region of this opening. Even at the lower dissected surface the sac completely closed off the isthmus. With the hand within the amniotic cavity, it was

possible to trace the limits of the still attached placenta. The placenta was somewhat bilobed and was attached over the anterior surface

fundus in the midline and at other points including the margins of tear and rupture. In the region of the fundus in the midline

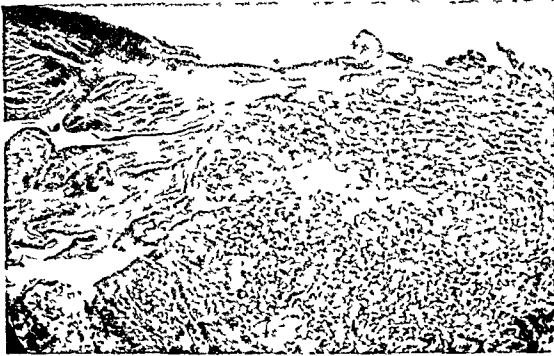


FIG. 7. A low magnification of a section taken to include uterus and adjacent placenta along the line of uterine rupture. The thick hypertrophied wall of the uterus is seen to taper gradually from left to right where it is finally represented by a thin band of muscle fibers. The relation of the placenta to the uterus is well preserved. There is no unusual ingrowth of trophoblastic tissue. A narrow zone of decidua cells separates muscle from the chorionic tissue. The large blood spaces in the wall of the uterus stand out conspicuously.  $\times 5$ .



FIG. 8. A higher magnification showing that portion of the field as seen in Figure 7 just along the line of rupture. It is apparent that rupture has occurred in this area at a point where a sinus becomes continuous with the intervillous spaces. The wall of the sinus adjacent to the placenta shows a channel through which chorionic villi may be easily traced. A small tab of red blood cells and fibrin is loosely adherent at this point. The wall of the sinus may be followed through to an abrupt end that is torn and curled back against the adjacent serosa. It is obvious that at this point of rupture the only partition between placenta and peritoneal cavity is the single wall of a blood sinus and its overlying somewhat edematous serosa. The underlying placental tissue is well formed. The decidua stands out clearly. A narrow band of fibrin, Nitabuch's membrane, separates decidua from the overlying muscularis. There is no unusual invasion. The villi are well formed. The intervillous spaces are free.  $\times 13$ .

of the uterus, over the fundus and over a large portion of the posterior wall. Somewhat more of the placenta was to the right of the median line. Both lateral surfaces of the uterus were free. With one hand in the amniotic cavity, it was possible, without any pressure, to bring a palpating finger up through the rent in the anterior uterine wall, the only tissue separating the finger from the external surface being the amnion, chorion and few friable tags of villi. The placenta was already detached over an area on the anterior uterine wall about the size of the palm of one's hand. This corresponded to the zone between the lower tear and the recent surgical incision.

The extent of the placenta could be seen more clearly after the uterus was opened. The placenta was somewhat bilobed and the cord was attached near its narrowest portion.

Several sections were taken through the

there was a depressed scar-like line covered by loose edematous adhesions. When this was sectioned it was found to be gray, firm, leather-like, and about 0.5 cm. in width; contrasting sharply with the 2 to 3 cm. of thickness of the surrounding uterine musculature. The placenta was attached in this area just as firmly as in the nearby and more healthy zone. A section taken through the area of the tear showed that the wall of the uterus gradually became thinner as it reached the line of rupture. The placenta here was somewhat loosely attached.

**Gross Diagnosis.** A gravid uterus showing a double midline rupture at the site of a former midline scar (Spinelli operation three years before); old healed perimetritis with scarring of the serosa; Porro cesarean specimen of uterus.

**Microscopic Findings.** A gravid uterus with placenta attached. The placenta was mature,

well developed, and showed no evidence of any pathological condition. Several sections were prepared from the wall of the uterus to include the hypertrophied wall, the old midline scar and the margin of rupture. The myometrium was well developed. There was an old midline scar containing small bundles of hypertrophied muscle fibers, and fragments of old suture material. There were foci of lymphocytes and plasma cells in this area of scar formation.

Of special interest in this scar area was the presence of edema, swelling, necrosis, disintegration and dissolution of collagen. Isolated muscle fibers and clusters of muscle fibres showed vacuolization, atrophy and gradual disappearance.

Sections taken just at the line of rupture showed a stretching and rapid thinning out of myometrium. At the exact point of rupture in one area a large venous sinus was torn across.

Some of the arteries adjacent to the scar and rupture showed an unusual degree of intimal sclerosis and narrowing of the lumina.

*Microscopic Diagnosis.* This showed repair of old surgical incision with scar formation, degeneration of scar, rupture of scar, with hemorrhage: pregnancy. *Note:* I believe the changes in the scar adjacent to the actual area of rupture gave one a good impression of why rupture had occurred. There was a recent degenerative change going on in this scar with digestion of collagen. I believe that this process had been of particular importance in the mechanism of rupture. There was no indication that the placenta was unusually invasive and no evidence of malignancy. (Examined by H. E. MacMahon.)

*Convalescence.* This was free from complications. There was no undue rise of temperature, pulse or respirations. The two drains had been removed by the fifth day, and the convalescence was that which follows a simple hysterectomy. The patient was discharged on April 26, 1941, twenty-eight days after operation, and the following discharge note was made: The abdominal incision, including the drainage tract, is healed throughout. There is no induration or tenderness. The vaginal examination shows a relaxed perineum but no cystocele or rectocele. The cervix, through which a drain had been

inserted, is closed, it is parous, relaxed, healed, without erosion or ectropion. The uterus has been removed supravaginally, the adnexa feel normal, and there were no masses or areas of tenderness in the pelvis.

The baby was gaining weight rapidly on a formula.

On June 5, 1941, the patient reported to the office for further examination. The abdominal and vaginal findings were those of April 26, 1941. The baby then weighed thirteen pounds (5,928 Gr.), and was doing well. The mother's general health was excellent.

#### SUMMARY

The woman who has had a Spinelli operation in the treatment of inversion of the uterus is exposed to the danger of rupture of the uterus in a subsequent pregnancy, because of the existence of a scar extending from the uterine fundus to the os externum of the cervix. One on whom I had performed this operation on May 27, 1938, reported to me in late pregnancy. It was decided to deliver her by cesarean section, and the date of the intervention had been arranged for two weeks before the expected term in order to avoid the strain of the last two weeks of gestation on the uterine scar. Three days before this appointed date, without any effort on her part, and while she was in bed, her uterus ruptured. She was transferred to the hospital as soon as possible where a cesarean-hysterectomy was performed, following which a blood transfusion was administered. The convalescence was uncomplicated and the mother and baby were discharged from the hospital in good condition.

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# ACUTE PERFORATED PEPTIC ULCERS

## AN EIGHTEEN-YEAR SURVEY

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IN a recent review of the subject of acute perforated ulcers, Eliason and Ebeling collected 5,061 cases from various clinics, both here and abroad with a mortality for all cases of 23.7 per cent. Their paper has prompted an investigation into all acute perforations encountered over an eighteen-year period (1923 to 1940) at a metropolitan hospital (Jewish Hospital of Brooklyn) where the surgery was performed by thirty surgeons including the resident staff. The statistics were collected from both the private as well as the ward records.

It is true that the literature is replete with reviews on this subject, but only by frequent and repeated analyses can a method of procedure in this acute emergency be crystallized.

### GENERAL

The total admissions to the medical and surgical divisions during this period amounted to 132,115. There were 154 consecutive cases of acute perforated peptic ulcers or an incidence of one case in 858 admissions. (Table 1.) The greatest frequency occurred in 1926, with one in 426, and the lowest in 1933, at which time there was only one perforation in 2,063 admissions. Three patients were admitted in extremis and died without operation.

### AGE

The youngest patient was seventeen years of age with a known history of ulcer since the age of eight. He subsequently had a gastroenterostomy performed for obstruction. Following this, he developed signs of both a penetrating duodenal ulcer and a gastrojejunal ulceration. A subtotal gastrectomy of the Hofmeister type was done recently (March, 1941). Six patients were

under twenty years of age. The oldest, seventy-one, had a prepyloric gastric perforation and recovered following simple closure. There was no preponderance in any one age group. (Fig. 1.) Perforations were less frequent under twenty and over sixty years, with an equal distribution in the

TABLE I  
HOSPITAL INCIDENCE

Year	Admissions	Perforations	Incidence
1923	4,803	9	1:530
1924	5,549	7	1:790
1925	5,163	13	1:400
1926	5,125	12	1:425
1927	4,976	8	1:620
1928	4,977	4	1:1240
1929	7,095	11	1:645
1930	7,848	12	1:650
1931	8,592	11	1:780
1932	8,684	7	1:1240
1933	8,272	4	1:2070
1934	8,281	6	1:1380
1935	8,851	9	1:980
1936	9,148	5	1:1830
1937	8,782	8	1:1100
1938	8,357	6	1:1390
1939	8,806	10	1:880
1940	8,806	12	1:735
Total . . .	132,115	154	1:858

intervening decades. Stern, Nessa and Perkin have recorded the case of a two-day old infant, who was operated upon for perforated gastric ulcer. Death was due to peritonitis.

### SEX

There is a marked preponderance of this condition in the male. (Fig. 1.) Eliason and Ebeling found the ratio to be 31:1. Barber presented a greater frequency with one female to five males. Unique in the statistical reviews are Sallick's seventy-four and Brahms' sixty-two perforations, all occur-

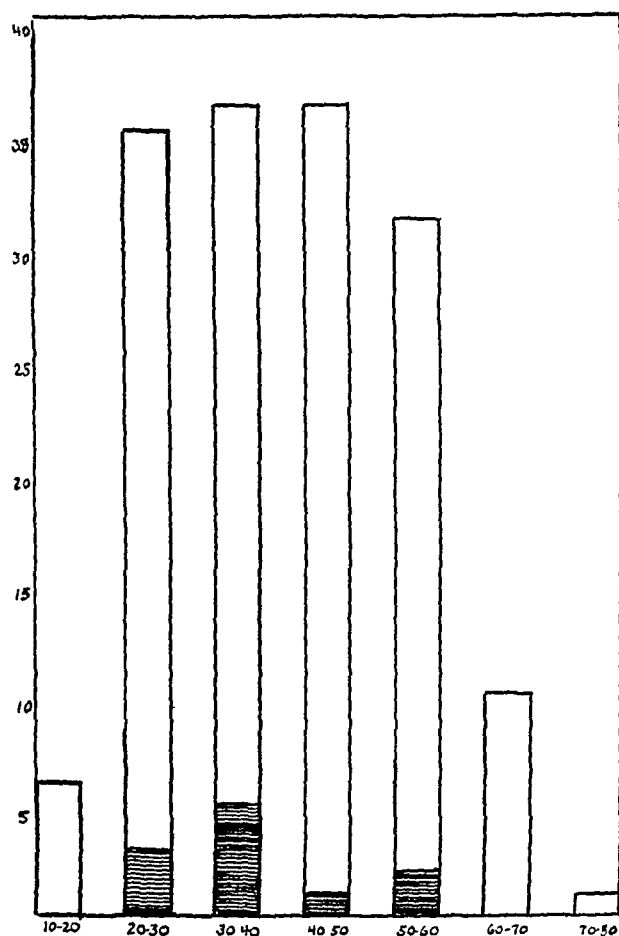


FIG. 1. Age and sex incidence: heavy column—female, 11; blank column—male, 143.

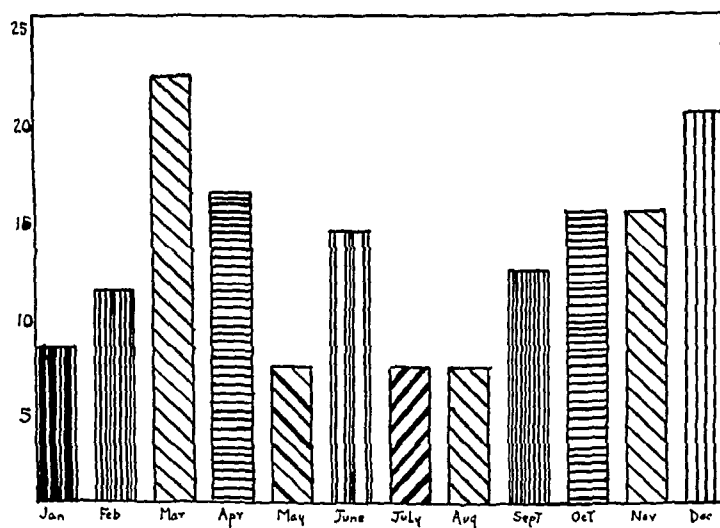


FIG. 2. Monthly incidence.

ring in men. In this series of 154 cases, eleven were found in women and 143 in men, a ratio of 1:13.

#### SEASONAL INCIDENCE

There was a mild seasonal and monthly variation. (Fig. 2.) May, July and August were the low points in this series with seven perforations. The frequency in the Spring and Fall was two and three times as great. There were twenty-two cases in March and twenty in December. This apparent preference during cold weather did not hold for January, at which time only eight occurred. Nor is the statement entirely true that few perforations take place during the warm season when we note that fourteen patients came to operation in June.

#### PREVIOUS HISTORY

Twenty-four (15.6 per cent) gave no previous ulcer history and became aware of the presence of the ulcer only by the occurrence of the perforation. The others (84.4 per cent) had had symptoms suggestive of ulcer or had been treated for an ulcer for periods varying in duration from a few weeks to twenty-five years. Only eight had had roentgen ray evidence of an ulcer. Five had had x-rays taken but no lesion was found at the time. Six patients were on a diet, but in general the medical therapy was inadequate. About 50 per cent resorted to alkalis or food for the relief of the symptoms. Perforation can occur even in the presence of an adequate medical régime. This was found to be the case in twenty-seven of fifty-six patients observed by Eliason and Ebeling. In Brown's series of one hundred perforations, fifty were under medical care at the time the catastrophe occurred.

#### ACTIVITY AND PERFORATION

In many cases no immediately exciting factor could be ascertained. Thirteen were awakened from sleep by the sudden acute pain. Two were driving their automobiles; five were lifting heavy weights; three were straining at stool and two were undergoing

a gastrointestinal roentgen investigation at the time of perforation. Only twenty-five patients were occupied in sedentary work. These included lawyers, students, clerks, a musician, an engineer, a broker and a school teacher. The other men were engaged in heavy labor. These were plumbers, longshoremen, painters, machine operators, brick layers and handy men. The women were all occupied with house work.

That trauma can play a part in the causation of perforation is exemplified in the case of a thirty-two-year old houseman who was hit in the epigastrium by the head of a child who ran into him. He felt abdominal pain following the injury, but did not seek medical attention until seventy-two hours later. At this time, he had signs of a general peritonitis and died eight hours following admission. Necropsy revealed the presence of a perforated duodenal ulcer.

#### TIME INTERVAL AND MORTALITY

Opinion is unanimous that the most favorable prognosis is in the early case. Graham, in presenting fifty-one perforations with but one fatality, attributes this low mortality rate to the fact that the

TABLE II  
TIME INTERVAL AND MORTALITY

Time—Hours	No. Cases	Fatalities	Mortality Per Cent
1-6.....	57	3	5.2
7-12.....	48	7	14.6
13-24.....	23	4	17.3
25-48.....	10	3	30.0
Over 48.....	8	6	75.0
Not stated.....	5	0	
Total.....	151	23	

average time interval for all his patients was about seven hours between the onset of symptoms and operation. His excellent results are convincing proof of the necessity of early diagnosis and proper surgical intervention. Fifty-seven patients were admitted within six hours with three deaths (5.2 per cent). With the increase in the time



interval, the mortality rose with the high of 75 per cent in eight patients operated upon forty-eight hours after perforation. (Table II.)

#### RECURRENT AND MULTIPLE LESIONS

Only three patients had recurrence of perforations. One had had a gastric ulcer perforation seven years previous to a perforation at the first portion of the duodenum. A second patient had two perforations within four years, supposedly at the same site in the duodenum, and the third suffered two perforations within one year.

The following is an unusual case in which two perforations, one duodenal and the other gastric occurred simultaneously.

**CASE I.** The patient was a fifty-seven year old man with a known ulcer history of ten years' duration. He was admitted to the genito-urinary service for an acute retention of urine. After catheterization, during which about one and one-half liters were removed, his abdominal pain continued. His abdomen was tensely rigid and signs of an acute peritonitis were present. A flat plate of the abdomen at first showed only distended intestine, but a second one the following day revealed the presence of a pneumoperitoneum.

At operation, two perforations were visualized, one in the prepyloric anterior surface of the stomach and the other in the first part of the duodenum. Both were closed with simple sutures. Culture of the abdominal contents showed *Staphylococcus aureus* and *Streptococcus hemolyticus* to be present. His immediate postoperative course was good but several days later he developed an erysipelas and signs of uremia and died twenty-one days after operation. Necropsy confirmed the operative findings. In addition, he had renal abscesses, pneumonia and a carcinoma of the prostate.

Perforated ulcers occur usually on the anterior wall of the stomach or duodenum, while bleeding ulcers are more frequent on the posterior wall, particularly in the duodenum. When both signs of perforation and bleeding are present, a search should be made for two lesions. Occasionally, a bleeding ulcer may be quiescent at the time of perforation and may be overlooked at

the time the perforation is closed. A situation such as this may not only cause a rather stormy convalescence but can result in a fatality if allowed to continue.

**CASE II.** A fifty-year old male patient was admitted with a diagnosis of an acute perforation of the duodenum. He had a known ulcer of fifteen years and but little medical therapy. The perforation was found on the anterior wall of the first portion of the duodenum and this was closed with simple sutures and no drainage employed. Culture of the peritoneal contents showed the presence of *Staphylococcus aureus* and *Streptococcus nonhemolyticus*. He had a normal convalescence for five days and then began to vomit large quantities of blood. He was treated conservatively with infusions and transfusions and the bleeding ceased. Three weeks after operation he again had several severe episodes of hemorrhage. His blood pressure at this time was 80/50. He was given blood transfusions several times until his pressure reached 114/90. His condition was serious, as he continued to bleed. In the hope of stopping the hemorrhage, he was taken to the operating room. The duodenum was opened and a bleeding ulcer on the posterior wall was found. Attempts to control this were made by several sutures through the base and then a subtotal gastrectomy was performed. He died the following day and necropsy revealed an ulceration through the wall into the superior pancreaticoduodenal artery.

Another unusual finding was the simultaneous occurrence in a fifty-year old male of an acute perforation in the duodenum and an acute hydrops of the gallbladder due to a cystic duct obstruction by a stone. The perforation was diagnosed preoperatively, but the other lesion was unexpected and fortunately not overlooked. The perforation was closed and the gallbladder removed. He made an uneventful convalescence.

#### DIAGNOSIS

In the majority of patients, the clinical picture is characteristic. The sudden onset of acute pain, usually epigastric in location, that throws the patient into a state of collapse or prostration is typical. He is doubled up into a jack-knife position from which he straightens out only with difficulty and with apprehension that any

movement will increase his suffering. The pain early is present over the site of perforation, but soon becomes general. Reference of pain may be to one or both shoulders which is a good differential point from acute appendicitis. Muscular rigidity is extreme and the patient frequently volunteers the information that he could feel his "belly harden up." The board-like abdomen persists even after the administration of sedatives. The temperature in the early stage is normal or even subnormal. The pulse may be quickened, but seldom goes beyond 90 in the first few hours. Respirations are costal in type and shallow, due to the muscle splinting. Vomiting and nausea were not constant, but occurred in about 50 per cent of the cases. Retching was present in another 25 per cent. None of these symptoms were noted in 25 per cent.

A moderate leucocytosis was usually present and occurred early in the condition. There was a definite relationship between the total white blood count and the mortality. (Table III.) In sixty-eight cases with a

TABLE III  
LEUCOCYTOSIS AND MORTALITY

W.B.C. Count	No. Cases	Deaths	Mortality Per Cent
Over 15,000.....	68	5	7.3
10,000-15,000.....	41	6	14.6
Under 10,000.....	21	11	52.4
No count.....	24		

leucocytosis of 15,000 or over, the mortality rate was 7.3 per cent. In counts between 10,000 to 15,000, the rate doubled; and when the white cell response was under 10,000, the death rate reached 52.4 per cent.

Obliteration of liver dullness was noted in forty patients. In seventeen others it was definitely absent. The limitations of this sign as a diagnostic aid is obvious. A distended loop of intestine, lying between the liver and the abdominal wall, will produce a tympanitic sound on percussion. Turning the patient on his left side and then percuss-

ing the liver in the midaxillary line may be of some help. Generally, this sign is of little value and other findings are of more significance.

#### PNEUMOPERITONEUM

Roentgen ray evidence of the presence of a pneumoperitoneum has been very helpful in making the diagnosis of a ruptured viscus. This should be taken in the erect and not in the prone position. One patient was delayed twenty-four hours because the flat plate of the abdomen showed no gas under the diaphragm. The exposure had been taken with the patient lying down. A re-examination done the following day with the patient in the erect position showed a small but unmistakable collection of air. A negative film is of no significance, but a positive finding is almost pathognomonic. Johnson advised that the patient be turned first on his left side for a few seconds and then shifted to the erect posture for the exposure. By this method he found a pneumoperitoneum in 83 per cent of forty-two cases of perforated ulcers. During the first fifteen years of this series, the x-ray was resorted to on only four occasions, with a positive finding in two (50 per cent). During this period a wrong diagnosis was made in 24.6 per cent of the cases seen. During the past three years, twenty-eight patients with perforations were all properly diagnosed. Roentgen ray visualization was resorted to in twenty, and in sixteen of these, a pneumoperitoneum was noted.

The most frequent errors in diagnosis were acute appendicitis in twenty-three (15 per cent), acute cholecystitis in six (3.9 per cent), of whom four were females, and intestinal obstruction due to malignancy in one case. The correct diagnosis in the entire series was made in 124 (80.5 per cent).

#### ANESTHESIA

Spinal anesthesia was employed in sixty-one but had to be augmented in nineteen by some form of inhalation anesthetic. This was caused either by failure to obtain suffi-

cient relaxation or to prolongation of the operation beyond the working time of the spinal anesthetic. This failure of spinal anesthesia to produce the desired effect has been noted by many observers, and different explanations have been offered; none of which, however, proves so adequate or so logical as that which blames faulty technic in the administration as the sole cause of the failure. The high mortality of 25 per cent in those cases in which local infiltration was used is explained by the fact that this method was the anesthetic of choice in the late and bad risk patients. The mortality was higher in operations under a general than a spinal anesthesia. (Table iv.) Fallis also found this to be true in his review of 100 cases of perforations at the Henry Ford

TABLE IV  
ANESTHESIA AND MORTALITY

Anesthesia	Re-covered	Fatal	Mortality Per Cent
Spinal.....	42	7	14.2
Spinal-general.....	19	0	0.
General.....	47	11	18.9
Local-general.....	10	1	9.0
Local.....	9	3	25.0
Not recorded.....	1	1	
Total.....	128	23	

Hospital. He attributed the apparent superiority of spinal over general anesthesia to the fact that spinal operations were done during the latter years of his series and came into popularity during a period when gastric lavage, oxygen tents, etc., were employed with more regularity in the postoperative care of the patient.

#### SITE OF PERFORATION

Over 90 per cent of all perforations in the duodenum occur in the first part just beyond the pylorus and usually in the anterior wall. (Table v.) Occasionally, the site involved is the superior surface and less frequently on the posterior wall. In this series, 128 perforations were in the duodenum and only nineteen in the stomach.

Two were described as "pyloric" in location. One patient had two perforations, one in the first portion of the duodenum and the other on the anterior wall in the prepyloric region of the stomach. The mortality in the duodenal group was 14.8 per cent as compared with a death rate of 21 per cent in the gastric cases. McCreery, in reviewing 170 perforations at Bellevue Hospital, showed gastric to be twice as frequent as duodenal involvement. Sallick's figures in seventy-four cases also found the stomach more frequently the site of perforation. Williams and Walsh, on the other hand, recorded four times as many duodenal as gastric ruptures. None of the eleven female perforations were in the stomach.

TABLE V  
SITE OF PERFORATION

Site	No. Cases	Fatalities	Mortality Per Cent
Duodenal.....	128	19	14.8
Pyloric (?).....	2	1	50.0
Gastric.....	19	4	21.0
Duodenal and gastric..	1	1	100.0
Not recorded.....	4	1	
Total.....	154	26	

#### BACTERIOLOGY

Marshall Davison and his colleagues have shown that the peritoneal culture usually is sterile during the first six hours and the convalescence in these patients is smooth. However, when the fluid from the abdomen contains organisms, the prognosis should be guarded. Clavels and Gellie have also made this observation in a series of cases in which 90 per cent of the patients with sterile cultures recovered and had no complications, while in the group with positive cultures, 50 per cent succumbed.

From 1923 to 1937, the peritoneal fluid was examined for organisms in only twelve cases and the findings were significant. In eight of these, the fluid was sterile and although one patient had delayed seventy-

two hours and three others did not come to operation until after six hours, all recovered. On the other hand, each of the four patients with positive cultures died. During the last three years, in twenty-eight perforations operated upon, cultures were taken in nineteen. Thirteen of these cultures were sterile and all the patients recovered. Of the six patients with positive findings in the fluid, three (50 per cent) died. For the entire series there were twenty-one sterile cultures with no fatalities and ten positive with seven (70 per cent) deaths. The offending organisms were staphylococcus, streptococcus, hemolytic and nonhemolytic, and *Bacillus coli*. (Table VI.)

TABLE VI  
CULTURE OF THE PERITONEAL FLUID

Period	Sterile	Died	Non-sterile	Died	Mortality Per Cent
1923-1937	8	0	4	4	100.0
1938-1940	13	0	6	3	50.0
Total...	21	0	10	7	70.0

#### OPERATIVE PROCEDURE

Simple closure of the perforation was done in 143 patients. This method utilized either one or two purse-string sutures, or two rows of Lembert sutures or a combination of both a purse-string and several interrupted sutures. A small piece of adjacent omentum was tied over the closure. In two patients the method of closure advocated by Graham was employed. No attempt was made to close the perforation tightly, but three interrupted sutures were loosely tied over an omental patch placed over the perforation. Five patients, in addition to simple closure, had a gastroenterostomy performed at the same time. Two patients had pyloroplasty of the Heincke-Mikulicz type and one had an excision of the ulcer area and closure. All deaths in this series were in those closed by simple suture. Consideration, however, must be given to the fact that all late cases,

and those considered to be bad risks, were treated in this manner. Gastric resection as a primary procedure was not performed in any case.

The choice of procedure has been a matter of much disagreement. Guthrie found that over 90 per cent of simple closures needed no further surgery and in every patient that died, autopsy revealed that neither a gastroenterostomy nor a partial gastrectomy would have reduced the mortality. McCreery believed that closure alone is a more satisfactory procedure than gastroenterostomy and closure, and in selected cases when necessary, a partial gastrectomy should follow.

Kerr, in a follow-up of his cases, found that 65 per cent were symptom free or almost entirely cured one to fourteen years after simple closure. Tondeur reported good results in 54 per cent of his patients. In another 30 per cent, a gastroenterostomy brought the satisfactory results to 84 per cent. White and Patterson record similar satisfaction with simple closure and conclude that partial gastrectomy as a primary operation is never justified. Consideration of a perforated peptic ulcer as an emergency requires immediate and rapid action. The operation of choice should be that which will help the patient through his immediate danger. The majority of British and American surgeons favor simple closure of the perforation. The procedure takes but a few minutes, is simple to do and does not require any unusual skill. Even those investigators who show poor results in 65 per cent of their cases and for that reason advocate more radical treatment must agree that in 35 per cent of the cases, unnecessary and meddlesome surgery will result.

#### DRAINAGE

There is no unanimity of opinion on the subject of drainage of the abdomen. Eliason and North state that drainage for a few days can do no harm. However, they are against prolonged drainage which is not necessary. They collected statistics on this

subject and divided the cases into three groups: First, those patients who were drained routinely; second, those who were drained frequently; and third, those who were drained only when in a late stage. They found the mortality highest in the first group, and least in the last, that is, in those who drained only in a late stage. Shawan in reviewing 389 perforations showed the present tendency to drain only the late ones. The policy at the Henry Ford Hospital, according to Fallis, is to drain all patients in whom there has been peritoneal soiling. The statistics from Bellevue Hospital reveal that drainage is rare. Much reliance is placed upon the proper and thorough cleansing of the abdomen and leaving the rest up to the ability of the peritoneum to take care of itself. Secondary abscesses are treated as they arise.

During the early years covered by this report, there were no basic rules followed for drainage. Sixteen patients coming to surgery within six hours were drained, while of those in whom the delay was at least twelve hours, twenty-one were drained and eighteen were not. During the last few years there has been less tendency to drain any patient and when it was done, it was only because gross contamination was present and the cases were in a late stage. (Table VII.)

TABLE VII  
DRAINAGE

Time	Recovered		Fatal	
	Yes	No	Yes	No
1-6 hours.....	13	40	3	1
7-12 ".....	14	26	7	0
Over 12 hours.....	12	15	9	3
Total.....	39	82	19	4

## OPERATIVE MORTALITY

There were 151 consecutive perforations of the acute type operated upon by thirty surgeons including the resident

staff. Twenty-three cases were fatal, giving an operative mortality rate of 15.2 per cent. There were three patients admitted in extremis and they died without surgery six hours, eight hours and two days later, respectively. All were given expectant therapy and autopsy revealed the cause of death as acute purulent peritonitis due to the perforation of a peptic ulcer.

In the first eight years, seventy-six patients were seen with a mortality of 17.1 per cent. The death rate dropped in the last ten years to 13.3 per cent for an additional seventy-five cases. Eliason and Ebeling collected 1,940 cases in the United States with a mortality of 25.9 per cent, and an additional compilation of 3,121 perforations with a fatal rate of 22.6 per cent from the European clinics. They contributed seventy-four of their cases and showed a death rate of 47.2 per cent. Shawan offered 307 perforations of which 25 per cent were fatal. More favorable are the figures of Gilmour and Saint (4.7 per cent in sixty-four), Sallick (10.8 per cent in seventy-four), Graham (one death in fifty-one) and Southam (no deaths in thirty-four). The mortality rate generally is lower in the smaller series of cases one encounters in the statistical reports. In our series, only one death occurred in thirty-four consecutive perforations from 1930 to 1933, but as the cases accumulated there was a rise in the fatalities.

Graham attributes his excellent results to the alertness of the physician in making an early diagnosis and in bringing the patient to surgery without delay. Certainly the average time interval of only seven hours for all his cases indicates the speed which is so very essential in the treatment. Among Sallick's seventy-four patients were forty-nine perforations operated on within six hours with only one death. The average time interval for 151 perforations in this series was 13.1 hours.

Factors, aside from the perforation-operation time interval, over which the physician has very little control and which have some influence over the prognosis are

the age of the patient, the size of the perforation and the presence or absence of pyogenic organisms.

The mortality for all patients over forty years of age was 23.3 per cent as compared with the death rate of only 6.5 per cent in a similar number under forty years. (Table VIII, Fig. 3.)

TABLE VIII  
AGE AND MORTALITY

Age	No. Cases	Died	Mortality Per Cent
Under 40 years.....	77	5	6.5
Over 40 years.....	77	18	23.3

The larger the perforation, the more rapidly will the gastroduodenal contents spill into the general peritoneal cavity causing a sudden severe and extensive contamination. In very small perforations, the leakage is slow and the contamination slight at the time symptoms develop. The mortality of 70 per cent in patients with a positive culture as compared with a recovery of 100 per cent in that group whose cultures were sterile is sufficient indication of the importance of this factor in the ultimate prognosis of the case.

#### SUMMARY

1. One hundred fifty-four consecutive acute perforated peptic ulcers were presented.
2. The male to female ratio was 13:1.
3. No female perforations were gastric.
4. Perforations are most frequent between the ages of twenty to sixty years.
5. A relative infrequency was noted during the warm months.
6. Eighty-four and four-tenth per cent had had some ulcer symptoms prior to operation.
7. Three patients had recurrent perforations; one had two simultaneous perforations, one duodenal and the other gastric. A second patient had two kissing duodenal ulcers, one perforated, the other bleeding. A third patient had both a

perforated duodenal ulcer and an acute hydrops of the gallbladder.

8. Leucocytosis is the rule and is

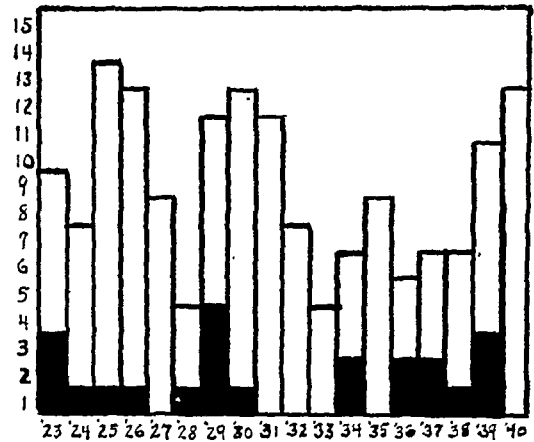


FIG. 3. Operative mortality 15.2 per cent. Heavy sections indicate fatalities—23; total number of cases 151.

present early. When absent, the prognosis should be guarded.

9. Pneumoperitoneum was present in 80 per cent of the cases in which roentgen rays were taken.

10. Duodenal perforations were seven times as frequent as gastric, but the mortality was greater in stomach perforations.

11. Seventy per cent of those patients with positive cultures of the peritoneal fluid died.

12. One hundred forty-three perforations were closed by simple suture alone. Five had an added gastroenterostomy.

13. Drainage was employed only in late cases during the past few years.

14. The elapsed time interval is the important factor in determining the prognosis. The age of the patient, size of the perforation and the presence of pyogenic organisms in the peritoneal fluid also play a part.

15. There were twenty-three operative deaths in 151 perforations, or a mortality rate of 15.2 per cent.

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# ENDOMETRIOSIS (ADENOMYOMA) IN POSTOPERATIVE SCARS

## AN ANALYSIS OF THIRTY-ONE CASES\*

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**E**NDOMETRIOSIS was first recognized about fifty years ago, but only in the last twenty years has it received much attention. It now is considered to be one of the more important gynecologic conditions.

By endometriosis we mean the condition in which tissue resembling endometrium grows elsewhere than in the cavity of the uterus. In reviewing cases in which operations had been performed at the Mayo Clinic for this condition from 1923 to 1934, inclusive, Masson<sup>8</sup> listed the situations of such ectopic endometrium, in the order of decreasing frequency, as: uterus, ovary, pelvic peritoneum, fallopian tubes, rectovaginal septum, ligaments of the uterus, sigmoid flexure, vaginal wall, laparotomy scars, umbilicus, ileum, bladder and appendix. Other situations which have been reported in the literature include: inguinal lymph-nodes and the canal of Nuck, labia majora and minora, thigh, arm and, possibly, the lungs.

### ETIOLOGIC ASPECTS

The etiology of endometriosis is unknown, although several theories as to causation exist. Probably the earliest of these explained the development of this condition from embryonic rests or remnants of the wolffian ducts or müllerian ducts. By some investigators the condition is considered to originate in the serosa of the peritoneum by a process of metaplasia, but other workers have said that it originates in the true endometrium and that it repre-

sents tissue growing from cells transported from the lining of the uterus. This migration is explained variously as metastasis through the blood and lymph channels, direct invasion or implantation. When the numerous situations of endometriosis are considered, it is difficult to explain the origin of this condition on the basis of one theory. Thus, direct invasion seems a feasible explanation for endometriosis of the uterus; a metastatic origin seems the only logical one for the disease as it occurs in the lungs; and metaplasia of the peritoneum, or implantation by means of retrograde menstruation can more logically explain the occurrence of the condition on the peritoneal covering of the pelvic or abdominal viscera than can other theories.

Authors have explained endometriosis found in laparotomy scars on the basis of one or the other of the preceding hypotheses. The majority of writers uphold the idea that this aberrant endometrium originates from true endometrial cells transplanted at the time of a surgical operation, or that direct invasion occurs from the exposed lining of the uterus or tubes or from misplaced endometrium that is present elsewhere in the abdominal cavity. The fact often is cited that endometriosis in laparotomy scars follows surgical operations on the uterus and tubes in the vast majority of cases. Hosoi and Meeker reviewed eighty-seven cases in which such an occurrence had been reported in the literature prior to 1929. In thirty-one cases endometriosis had followed ven-

\* This series includes reports of cases previously published by Mahle and MacCarty, Lemon and Mahle, and Masson and Marble.



tral fixation operations on the uterus; in twenty-eight, salpingectomy, oophorectomy or both; in nineteen, cesarean section; in fifteen, appendectomy; in five, hysterectomy, and in the remainder, miscellaneous pelvic operations. Wespi and Kletzhandler reported seventy-three cases of "cicatricial endometriosis," in five of which the condition followed cesarean section and in sixty-eight of which it followed abdominal interruption of early pregnancy. Hertzler stated that when the endometrium has been exposed at the time of an abdominal operation, endometrioma of the abdominal wall subsequently will occur in from 1 to 2 per cent of cases.

the time of operation in four of these fifteen cases some type of intra-abdominal procedure was performed other than that which concerned the tubes or uterus, such as appendectomy and similar operations. In the four remaining cases of this group of fifteen the operation consisted solely of suspension of the uterus. In four of the total number of thirty-one cases the condition followed cesarean section; in four, salpingectomy; in two, hysterectomy; in two, myomectomy; in one, simple appendectomy; in one, drainage of an appendiceal abscess; in one, inguinal herniorrhaphy, and in one case the condition was listed as following some type of pelvic operation

TABLE I

ANTECEDENT OPERATION, SYMPTOMS, TREATMENT: THIRTY-ONE CASES OF ENDOMETRIOSIS IN POSTOPERATIVE SCARS

Antecedent Operation	Cases		Symptoms, Observations	No	Treatment	Cases No
	No	Per Cent				
Uterine suspension	15	48.4	Pain or tenderness	26	Local excision only	7
Cesarean section	4	13	a. Only at menses	9	Local excision, irradiation	2
Salpingectomy	4	13	b. Continuous, worse at menses	14	Local excision plus other procedures to cure endometriosis	5
Hysterectomy	2	6.4	c. Not related to menses	3	Local excision, other procedures unrelated to treatment of endometriosis	16
Myomectomy	2	6.4	Nodule	27	Biopsy and irradiation	1
Drainage appendiceal abscess	1	3.2	a. Swelling at menses	5		
Appendectomy	1	3.2	Bleeding	4		
Inguinal herniorrhaphy	1	3.2	a. Only at menses	2		
"Pelvic operation"	1	3.2	b. Other times in cycle, but worse at menses	2		
Total	31	100.0	No symptoms, palpable nodule only	1	Total	31
			No symptoms, no palpable nodule	1		
			Nausea, vomiting at menses	1		

In the thirty-one instances of endometriosis in postoperative scars seen at the Mayo Clinic, and proved by pathologic study of the specimens, fifteen, or 48.4 per cent, had followed uterine suspension operations. (Table 1.) In seven of these fifteen cases some other procedure was performed on the uterus and tubes at the same operation, such as dilatation and curettage, salpingectomy and the like. At

performed elsewhere, the nature of which is not known.

In many of these procedures on the uterus and tubes, the linings of these organs are not exposed, but some adherents to the theory of the migratory origin of the condition explain that contamination of the edges of the abdominal wound is caused by the needle or suture inadvertently passing through their linings.

Nicholson<sup>12</sup> and others have upheld the theory that endometriosis originates in the peritoneum by a process of metaplasia to explain the occurrence of the lesion in postoperative scars, for the theories as to the origin of the condition by implantation or invasion do not satisfactorily explain all instances of the disease, and in particular, those that follow surgical operations on structures other than the uterus and tubes, and those in which the lining of the uterus or tubes is not exposed when the operation is performed. Such commentators contend that bits of peritoneum are caught in the wound, and that in this abnormal situation, metaplasia to endometrial tissue takes place. On the other hand, Sampson, explaining these cases on the basis that the condition is caused by the migration of endometrial cells, pointed out that manipulation of the tubes and uterus might cause slight soiling of the operative field, with endometrial tissue escaping by way of the ostia of the tubes. If this were true, endometriosis of the peritoneum would be expected to be associated in the majority of cases of endometriosis of postoperative scars. That it is not true is shown by the paucity of such observations in reported cases. Endometriosis of the peritoneum occurred only once in our series of cases.

To refute the theory that endometriosis arises by invasion, Nicholson<sup>12</sup> reviewed twenty-eight cases of the disease reported in the literature up to 1926, and stated that in none was there evidence that the tumor in the abdominal scar was continuous with the lining of the uterus. Two years later, however, Sampson demonstrated that the tissue of the tumor in the abdominal scar was continuous with the tissue of the lining of the uterus, in two cases, but in one other case no such connection was found. The latter, he explained as originating from contamination of the edges of the wound by transplantation of endometrial tissue.

In ten of our thirty-one cases the tumor of the abdominal wall was found to involve, or was adherent to, the uterus or tubes. Eight of these tumors involved the uterus

alone; one was continuous with an endometrioma of the tube and one was continuous with an endometrioma which involved the uterus and round ligament. In all but four of these ten cases there was no evidence of connection with the lining of the uterus or tubes. In four cases a connection with the lining of these organs was strongly suggested, although not absolutely proved. In two of these cases the condition involved the uterus and followed salpingo-oophorectomy; in one case the condition followed uterine suspension, myomectomy and salpingo-oophorectomy on the right. In the other case the condition involved the left tube and followed an operation for uterine suspension.

#### INCIDENCE

Endometriosis occurring in a postoperative scar is a relatively rare condition. Since the disease was first described by Robert Meyer in 1903 there have been several reports of a single case or a few isolated cases. There also have been several analyses of cases previously reported in the literature, perhaps with the report of an additional case or two from the experience of the particular author concerned. Among 576 patients operated upon from 1923 to 1934, inclusive, for endometriosis, the condition having been proved as such by pathologists at the Mayo Clinic, Masson<sup>8</sup> found ten instances, or 1.77 per cent, of endometriosis in laparotomy scars. Fallas and Rosenblum reported that 0.83 per cent of 260 cases of endometriosis appeared in postoperative scars. From 450 to 500 cases of the condition were reported in the world literature up to 1941, but undoubtedly some of the cases were repeated. By far the largest single group of cases reported was that of Wespi and Kletzhändler, who reported seventy-three cases in which patients had been operated upon for the disease in one Zurich clinic in sixteen years.

We have been able to collect thirty-one cases of true endometriosis in postoperative scars from the records at the Mayo Clinic.

The patients were encountered from 1916 to 1941.

#### PATHOLOGIC ASPECTS

Endometriomas in laparotomy scars resemble endometriomas situated elsewhere



FIG. 1. Endometrioma in abdominal scar after cesarean section. Note the dilated uterine glands, the typical endometrial stroma, the close proximity to the skin and the invasiveness of the endometrial tissue (hematoxylin and eosin)  $\times 25$ .

in the body in that they consist of a single layer of glandular epithelium similar to uterine lining and are frequently associated with endometrial stroma. (Fig. 1.) These glands and stroma undergo the proliferative, differentiative and menstruating stages which occur during the menstrual cycle of normally situated endometrium, as well as the decidual reaction which accompanies pregnancy. This aberrant tissue is invasive, follows the paths of least resistance and may be encountered branching and winding amongst the dense fibrous tissue of the scar. Occasionally, smooth muscle is encountered in association with the endometrial tissue, although none was found in our series of thirty-one cases.

Because these misplaced uterine glands frequently have no outlet for their secre-

tions, cysts, filled with a mucoid or thin, fluid material, may be found, and not infrequently collections of old blood with hemosiderin may be encountered. (Fig. 2.) This results from breakdown and hemorrhage during the menses. Cellular debris, lymphocytes, large mononuclear cells and foreign-body giant cells frequently are observed.

In Meyers' case, a silkworm suture was found to be embedded in the center of the endometrioma, surrounded by cysts, tubules and cellular stroma. In one of our cases, in which hysterectomy had been performed elsewhere three years previously, the patient presented herself with a painful lower midline scar. On excision of the scar an endometrioma in which was embedded a silk suture was found in the lower margin. A case such as this one may be used by some investigators as evidence of transplantation of uterine epithelium by a contaminated suture, or invasion of the abdominal wall along the line of the suture. (This is evidence, it is true, but it is not conclusive evidence, for the two conditions may have been merely coincidentally present.)

The largest specimen in our series weighed 67 Gm. and was 10 by 6 by 3 cm. The smallest specimen was 1.5 cm. in diameter (Fig. 3), whereas the great majority of specimens were from 2 to 4 cm. in size and weighed from 5 to 15 Gm. In all cases except two a single tumor was present. In these two cases two nodules were present in each one. In one of these two cases endometriosis developed in a scar after drainage of an appendiceal abscess, and in the other case the condition occurred after an operation for uterine suspension had been performed. In the latter case a lower transverse incisional scar was found in each end of which was one nodule, joined in the midline by a thin strip of endometrial tissue.

"Cicatricial endometriosis," in which there is a sanguineous discharge, usually at the time of menstruation, must be distinguished from postoperative menstrual

fistula. Ballin stressed this fact and pointed out that a direct communication with the tubal or uterine cavity to the outside is

nal cavity. In one case the condition followed inguinal herniorrhaphy.

In several of our cases adhesions involv-

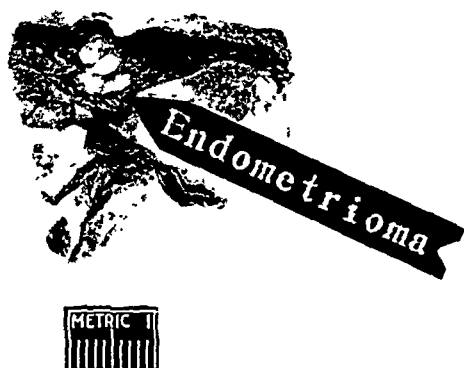


FIG. 2. Section of the endometrioma seen in Figure 1. Note the small, blood-filled cysts, and the lack of demarcation of the tumor.

present in the latter condition, whereas the former state represents a postoperative enclosure of endometrial tissue in the abdominal wall. It is possible that association of the two conditions might occur.

Endometriomas may be situated anywhere throughout the thickness of the abdominal wall; they may be subcutaneous only, may involve the skin or peritoneum, and may be continuous with endometrial tissue in the abdominal cavity. As already stated, ten of our patients presented tumors in the scar which were continuous with an endometrioma situated in the uterus or tubes, or which were adherent to these structures. One patient presented a tumor that was adherent to the round ligament within the abdominal cavity. This tumor had developed after uncomplicated appendectomy. These cases may represent invasion of the abdominal wall by intra-abdominal endometrial tissue or invasion of the intra-abdominal structures from an endometrioma of the abdominal wall. In seven cases the condition was found to involve the round ligaments outside the abdominal cavity. In six of these cases the disease had followed operations for uterine suspension at which time the round ligaments had been placed outside the abdomi-

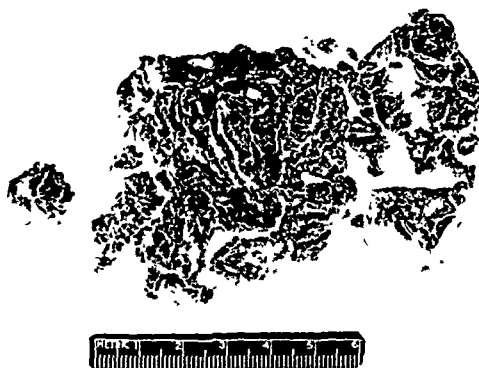


FIG. 3. Endometriomas removed from post-operative scars; the largest and smallest specimens removed from thirty-one patients.

ing some intra-abdominal viscus were present, but there was no evidence that endometrial tissue was contained within these adhesions. In other cases the mass was limited to the skin, subcutaneous tissue, fascia or muscle or several of these layers, and adhesions did not exist. Removal in these cases was obtained by local excision with or without opening of the peritoneal cavity.

#### CLINICAL SYMPTOMS AND OBSERVATIONS

Endometriosis in postoperative scars generally afflicts women of the third, fourth and fifth decades of life, during their active sexual lives, at an age when operation on the pelvic viscera is most frequently performed. Symptoms tend to appear a few months or years after the operation, and in a typical case a nodule appears in the scar, usually in the lower end, which becomes painful, and which may swell at the time of the menses. This nodule may become bluish, especially at the menstrual period, and may break down, discharging a sanguineous fluid. This is more likely to occur if the nodule is adjacent to, or involves, the skin.

In the cases reviewed by Hosoi and Meeker, the nodule appeared as late as twenty-six and a half years after the operation, and the lower end of the operative

scar was the site of predilection. Nicholson<sup>11</sup> reviewed cases reported in the literature, and found the interval between the operation and the onset of symptoms to vary from a few weeks to as long as twenty-one years, and he also stated that the tumors appear most frequently in the lower half of the operative scar. Wespi and Kletzhändler found that most patients presented symptoms within the first two years after operation, rarely immediately after, and on an average, 1.6 years after operation.

Some patients may present no symptoms or signs, except a nodule in the scar, as found by Heaney in his review of twenty-nine cases which had been reported in the literature. If symptoms occur, they usually are progressive in character.

*Analysis of Cases.* (Table 1.) In the thirty-one cases in which the patients were seen at the Mayo Clinic, the average age of the patients presenting themselves was thirty-six years; the youngest patient was twenty-three years old and the oldest was fifty years old.

Twenty-seven patients complained of symptoms produced by the endometrioma as their chief complaint. Three patients came to the clinic for reasons other than the condition under consideration, and the endometrioma in question was noted during the routine taking of the history or at the time of physical examination. In one case it was detected incidentally at the time of operation.

The symptoms of four patients began before or at the time the operative incision healed. The symptoms of nine patients started a year or less after operation. The longest interval after operation was twenty years, and followed drainage of an appendiceal abscess. The average interval between operation and the appearance of symptoms in twenty-eight cases was 4.2 years. In three cases the interval was not stated.

Pain or tenderness was experienced in the region of the incisional scar by twenty-six of thirty-one patients. Nine of these twenty-six patients had pain which was

associated only with the menstrual periods; fourteen experienced pain throughout the menstrual cycle, but the pain was increased during the menses. In three cases the pain was unrelated to the menstrual cycle. Five patients stated that the abdominal discomfort started, or was intensified, just before the onset of the flow, while three patients experienced the onset or aggravation of pain immediately after cessation of the menstrual period. In the remaining fifteen cases, it was stated that the onset of the menses coincided with the onset or intensification of pain. Five patients did not complain of pain or tenderness.

Twenty-seven of our thirty-one patients presented a palpable nodule in the scar. Nodules were not found above the umbilicus, because all involved scars were situated in the hypogastrium, lower quadrants of the abdomen or inguinal regions. All but two of the scars were either vertical or oblique. Situation of the nodule in the scar was mentioned in nineteen cases. In thirteen cases the nodules were situated in the lower half of the scar, in four cases in the upper half of the scar, in one case in the center of the scar, and in one case the endometrioma extended the whole length of the scar. Five patients volunteered the information that the nodule swelled during menstrual periods. Among four patients nodules were not palpable.

Four patients experienced a bloody discharge from the region of the scar. For two patients this discharge occurred only during the menstrual period, but in two cases it was noticed at other times as well, although in these two cases it was more marked at the time of menstruation than at other times.

Three patients presented no symptoms, but all had palpable nodules in the scar. From one of these three patients the largest specimen of endometrioma in our series was obtained; it was 67 Gm. in weight. A patient additional to those mentioned previously had no symptoms referable to endometrioma, and the nodule was not detected, clinically, preoperatively.

Various menstrual irregularities were present in some of our cases, but they can all be explained on the basis of lesions other than endometriosis. One patient complained of nausea, vomiting, pain, swelling and redness of the lower portion of the abdomen during menstrual periods.

#### DIAGNOSIS

*Simple Diagnosis.* When the condition is typical, diagnosis should not be difficult. When a woman, from twenty to fifty years of age, presents herself with a history of a previous pelvic operation and relates that at some time after the operation she noticed a painful lump in the scar, which is more painful at the time of catamenia, the diagnosis usually is obvious. Among those patients who do not present symptoms, but only a palpable nodule, biopsy may be necessary before the diagnosis can be made.

*Differential Diagnosis.* Endometriomas presented as asymptomatic nodules may be mistaken clinically for keloids, desmoid tumors, fibromas, unabsorbed sutures or other foreign bodies. Patients who present only a painful scar often have been told that they have "adhesions," "neuroma," "painful scar" or that they are "just nervous." Painful nodules not associated with the menstrual period easily may be misdiagnosed as neuromas or incarcerated omental hernias. Endometriomas that discharge sanguineous fluid at the time of the menses may be distinguished from uterine or tubal fistulas by the injection of colored fluid through the fistula and observance of the cervix to determine whether or not this same fluid makes its appearance. Roentgenograms made after the injection of iodized oil may be useful in establishment of the diagnosis.

The diagnosis of adenomyoma or endometriosis of the abdominal scar was made clinically in fourteen (45.2 per cent) of our thirty-one cases. In the remaining seventeen cases the diagnosis was first made correctly at the time of operation by the surgeon or the pathologist. The majority of incorrect clinical diagnoses were reached

prior to 1930, and relatively few thereafter; incorrect diagnoses were made probably because the entity has been more generally recognized in recent years than formerly.

#### TREATMENT

*Prophylaxis.* If the theory of implantation or invasion is correct, much may be accomplished to prevent the occurrence of this condition. Many surgeons advocate strict care in the performance of pelvic operations in which the endometrium is exposed. Gloves, towels and instruments should be changed before closure of the uterus or tubes, and care should be taken to touch the endometrium as little as possible and not to include the lining of the tube or uterus in sutures, whether the lining is exposed or not. Wespi and Kletzhändler stated that in their hands, with improved technic, the incidence of "cicatricial endometriosis" was decreased to a fourth of what it had been before the technic which they adopted was employed.

*Active Treatment.* Because endometriosis in postoperative scars seldom is associated with other types of intra-abdominal endometriosis, cure usually is easily obtained merely by excision of the nodule or scar. Such excision must be carried out carefully and widely, because the tumor is an infiltrating one and is not encapsulated. If any tissue remains, recurrence may be expected, as occurred in one of our cases. The patient in this case of recurrence had undergone cesarean section elsewhere seven years before she was seen at the Mayo Clinic. Two years after this operation she first noticed a lump in the incisional scar which swelled and became painful at the time of menstruation. This lump had been excised elsewhere at that time, and a "cyst" had been removed. The patient was relieved for a short time, but the same symptoms and signs reappeared. The nodule was widely excised at the Mayo Clinic and proved to be an endometrioma.

If another pelvic endometriotic process is present, whether or not it is continuous with the tumor in the abdominal scar,

other procedures probably will have to be carried out to obtain a cure. The endometrioma should be removed, whether removal requires hysterectomy or any other procedure, or, if it is too extensive the ovaries should be removed or irradiation therapy employed to reduce or obliterate ovarian function. The choice of these procedures depends on the technical difficulty that would be encountered, and the general condition and age of the patient.

In an analysis of our series of cases (Table 1), it is seen that cure was obtained in seven cases by means of local excision alone. In two cases, local excision was followed by irradiation therapy; and in five cases, a more extensive operative procedure was carried out to cure the endometriotic process which also was present in the abdominal cavity. In addition to removal of the scar tumor the following procedures were performed: subtotal abdominal hysterectomy and salpingo-oophorectomy on the right, hysterectomy and excision of a piece of omentum, salpingectomy on the left, salpingo-oophorectomy on the right, and, last salpingectomy on the left and excision of the left cornu of the uterus. In sixteen cases other unrelated operative procedures were performed, as well as local excision of the tumor. In one case it was technically impossible to remove the tumor, so excision of tissue for biopsy and postoperative irradiation were carried out.

#### SUMMARY

Thirty-one cases of endometriosis in postoperative scars were analyzed. It was found that in the majority of cases the lesion followed operations performed on the uterus or fallopian tubes, but that in the performance of most of these operations the lining of these organs had not been exposed. A few of the tumors seem to have originated from exposed portions of endometrium and to have invaded the abdominal wall secondarily, but others were definitely separated from the uterine lining.

The etiology of this condition is unknown, but, in most cases, the best evidence points toward transplantation or invasion (migration) of endometrium from the lining of the uterus.

The endometriomas in question resemble endometrium, histologically, and in one case an unabsorbed suture was presented, which may or may not represent the contaminating vehicle during the original operation. In a large number of cases in which the condition followed ventral suspension of the uterus, the round ligaments were involved with endometriosis, at those points at which they were sutured to the anterior abdominal wall.

Pain, worse at the menstrual period, and the presence of a palpable nodule, were most commonly complained of by the patients. Few of the tumors discharged a bloody fluid at the menstrual period. In a few cases there were no symptoms.

The diagnoses were made more often in the ten years prior to the time of this report, for the medical profession is now more aware of this entity than it had been formerly. The differential diagnosis most often includes, keloids, desmoids, fibromas, neuromas, incarcerated omental hernias and uterine or tubal fistulas.

If the condition is uncomplicated, cure may be obtained by wide excision. One instance of recurrence was encountered; undoubtedly the condition in this case was caused by inadequate excision at the time of the first operation.

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THE absence of pigment in the skin is leukoderma, achromia or vitiligo. It may throw the normal skin into such relief that it may be mistaken as being pigmented.

From—"Symptoms in Diagnosis"—by Jonathan Campbell Meakins (Little, Brown and Company).



# VAGINAL HYSTERECTOMY WITH PRYOR CLAMPS\*

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IT may seem presumptuous to suggest the reconsideration of an old and largely forgotten operation for removal of the uterus, but the interest in its technic, displayed by certain members of the New York Obstetrical Society during recent months, seems to justify a brief plea for its retention in our surgical armamentarium. Most pelvic surgeons select supracervical, total abdominal, or vaginal hysterectomy as the operation of choice in an individual case in accordance with the indications, but comparatively few ever remove the uterus vaginally with clamps. Thirty years ago laparotomies were much more hazardous than they are now, and vaginal hysterectomy enjoyed greater popularity because of its relative safety. While many gynecologists are enthusiastic advocates of the vaginal technic, the majority of operators use sutures and seldom rely on clamps alone. Conceding that the clamp method has certain disadvantages, its merits should not be forgotten, as it distinctly minimizes the risk in elderly women, diabetic, and very obese patients, and those with a compromised myocardium or impaired metabolism. To Kennedy of Philadelphia should go the credit for maintaining a modicum of interest in a valuable procedure which might otherwise have become obsolete. Although the percentage of cases in which I have used clamps is relatively small, all of the patients were poor risks for any other type of operation, and none has died. The zero mortality may fairly be attributed to the fact that the operations were all done under low spinal or cyclopropane anesthesia given by an expert, in less than ten minutes. With the exception of one case in which it was necessary to

remove an unsuspected ovarian cyst, and another in which there was little prolapse and a great deal of scar tissue, the hysterectomy averaged about six minutes.

## TECHNIC

After deeply circumcising the vaginal vault and pushing the bladder upward to free it from the cervix, the peritoneum in the cul-de-sac is opened and widely stretched with the fingers, which brings the lower attachments of the broad ligaments into view. The corpus of the uterus is then delivered through the posterior vaginal vault with rake retractors. The uterus is grasped with the left hand, the middle finger being introduced between the broad ligaments and extended up to the uterovesical space. By incising the uterovesical fold of peritoneum over the finger tip, and stretching this opening laterally, the bladder and ureters are afforded perfect protection and the broad ligament attachments are again well defined. The finger serves as a guard in keeping the intestines out of the way, acts as a retractor on the uterus, and aids in the correct application of the clamps. Pryor hysterectomy clamps are applied from above downward to secure the broad ligaments on each side, and the uterus is cut away. The clamps are then inserted as high as possible in the pelvis, and plain gauze drains introduced between and up to the tips of the clamps. Iodoform gauze should never be used for this purpose. After removing the clamp handles, a Pezzer retention catheter is placed in the bladder and a tight T-binder is applied over a heavy gauze pad.

The gauze packing is removed after forty-eight hours. At the end of seventy-

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two hours the clamps\* are gently unlocked and withdrawn, together with the retention catheter, under intravenous or light nitrous oxide anesthesia. The patient is kept in bed for twelve or fourteen days, during which period there may be a malodorous discharge, but no douches are given. Occasionally, there may be a little secondary vaginal bleeding between the eighth and twelfth day, which can be controlled by a hypodermic injection of morphine, and elevation of the foot of the bed. Re-packing the vagina is unnecessary. Kennedy and some other operators advise performing whatever plastic vaginal operations are needed on the eighteenth postoperative day. Personally, I prefer to defer such procedures for three or four months, because they would still further protract a long hospital confinement and I have found that the patients are in much better physical condition if given a reasonable

interval to re-establish their circulatory activity. In fact, the marked improvement in the general condition of many of these women, particularly those who have been relieved of a distressing prolapse, is striking.

The disadvantages of a clamp vaginal hysterectomy are the undesirability of attempting the operation unless the uterus is movable, the transitory but unpleasant vaginal discharge, the possibility of late slight postoperative bleeding, the unusually long period of hospitalization, the preclusion of doing coincidental plastic operations and the necessity for special instruments. On the other hand, the rapidity with which the operation can be completed, the conservation of the patient's vital resistance, the complete absence of shock, the safeguarding of the bladder and ureters, the freedom from postoperative complications and the smooth convalescence make it a valuable asset for substandard risks.

\* These clamps are now made in the United States by the George P. Pilling & Son Company, Philadelphia.



# ACUTE PERFORATED PEPTIC ULCER SYNDROME WITH SURGICAL MANAGEMENT

## REPORT OF 124 SURGICAL CASES

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THE mortality rate in perforated peptic ulcer shows a wide variation.

Eliason and Thigpen, reporting from a series of seventy cases, including both duodenal and gastric ulcers, give a mortality rate of 21.43 per cent.<sup>1</sup> H. L. Thompson, reporting a series of 500 cases, gives a gross mortality of 40 per cent.<sup>2</sup> R. R. Graham, reporting fifty-one cases, finds a rate of 1.8 per cent.<sup>3</sup> The reports from other writers show similar variations in the death rate of this disease. The mortality rate is lowest in the smaller selected group of cases. In the larger groups from urban hospitals the rate is higher, due to the delay of the patient in reaching surgery after perforation occurs, and to low physical reserve.

During the past several years the bulk of the literature on perforated ulcers has been concerned with the importance of the interval from perforation until operation and the efficacy of the simple closure. It is a recognized axiom that the sooner perforated peptic ulcers are operated upon the better the prognosis, and the consensus has been that simple closure incorporating the omental graft is the operation of choice. It is our purpose to stress, also, the importance of the etiological factors concerned in the location of this lesion and its perforating character and the surgical management

in its relation to the late results following recovery in certain selected cases.

Our report based on a study of 124 cases of perforated ulcer (all except eight patients were operated upon and those eight were confirmed at autopsy) corroborates previous studies that the time element is the most important factor in the mortality of this complication. Age, sex and color are important etiological factors in that 70 per cent of these cases occurred from the third through the fifth decade, 93 per cent occurred in the male, and 82 per cent occurred in the white race. The location of the ulcer was in the duodenum in 88 per cent of the cases, in the stomach in 10 per cent, and in the gastrojejunal stoma following gastroenterostomy in 2 per cent. Forty-five and eight-tenths per cent of all the cases were drained and the remainder were not. In this total of 124 cases there was an operative mortality rate of 18.5 per cent. Of this total, forty were personal cases, nineteen of which were private cases and twenty-one from Hillman (Charity) Hospital, while sixty-eight were from the general staff of Hillman Hospital from 1936 to 1940 and twenty-six from the general staff of the Baptist Hospital. The foregoing facts are summarized in the following table:

Location	Per Cent	Sex	Per Cent	Color	Per Cent	Age	Per Cent
Duodenum.....	88	Male.....	93	White.....	82	30 to 60 years.....	70
Stomach.....	10	Female.....	7	Colored.....	18		
Gastrojejunal stoma	2						

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The total number of deaths in this series of 124 cases was thirty-one. Eight of the patients were not operated upon and are not considered in calculating the operative mortality of 18.5 per cent. These cases may be divided into three groups: (1) the eight patients who were not operated upon; (2) those who were operated upon within twelve hours after perforation; (3) those who were not operated upon until more than twelve hours after perforation. An analysis of the group of eight patients not operated upon reveals that none sought admission until two or more days following perforation, and, due to their general condition and widespread infection, surgery was deemed inadvisable. In the second group, those operated upon within twelve hours, there were seven deaths. Of these, one had multiple duodenal ulcers and died of general peritonitis. In one the ulcer was not found and autopsy revealed jejunal ulcer with general peritonitis. The other five died of an overwhelming infection with general peritonitis.

An analysis of the seven deaths in the second group is of interest because as far as the time element is concerned the patients were operated upon soon enough, yet they expired:

Case No.	Age	Color	Sex	Duration of Perforation—Hours	Results
1	42	W	M	5	Multiple duodenal ulcers, drained, died of general peritonitis; ulcer closed
2	40	C	M	6½	Duodenal ulcer, simple closure with omental graft; died 7 days later; general peritonitis
3	46	W	M	12	Ulcer not found; autopsy revealed ruptured jejunal ulcer with general peritonitis
4	40	W	M	6	Duodenal ulcer, closed; drained; died 7 days later of general peritonitis
5	44	C	M	3	Gastric ulcer; excised; drained; died 7 days later of general peritonitis
6	56	C	M	11	Duodenal ulcer, closed with purse string; died 1 day following operation; general peritonitis
7	78	W	M	3	Duodenal ulcer; lived 4 days; died of general peritonitis

In the group not operated upon until more than twelve hours after perforation

there were sixteen cases, all of which had been perforated for at least twenty-seven hours. In our total of thirty-one deaths out of the entire series of 124 cases, there were no patients who had been operated upon between twelve and twenty-seven hours after perforation. In this last group all died of general peritonitis with various complications, such as pleurisy, lung abscess and wound infections. Of this entire group of twenty-three operative deaths, only two patients had pyloroplasties, seventeen had simple closures, two had gastric resections and two had gastroenterostomies, in addition to simple closure. (Fig. 1.)

#### DISCUSSION

In the discussion of peptic ulcer we wish to emphasize the relationship between its location and pathological features and its perforating character. The first or suprapapillary portion of the duodenum is the site of perforated peptic ulcers nine times as often as the stomach. This is due in part to the ischemia of its mucous membrane and the corrosive action of the acid gastric juice. Here when irritation is present healing occurs more slowly.

When an ordinary portion of the stomach mucosa is injured there is a production of mucin which serves as a protector and healing readily occurs. On the Magenstrasse, where the majority of gastric ulcers occur and where the mucous membrane is tightly stretched and no mucin is produced, healing occurs with difficulty. Perforated ulcers are occasionally seen here, but it is not the usual antecedent complication, since 70 per cent of the ulcers in this location, especially those occurring in proximity to the pylorus, undergo malignant changes. Furthermore, as contrasted to the anterior surface or the suprapapillary portion of the duodenum, the stomach being in close apposition in the rear to the posterior peritoneal covering the peritoneal cavity will not likely become flooded from the spill of the ulcer.

Thrombosis of the blood vessels of stomach or bowel occurring independently

or in combination with infected emboli from oral sepsis is responsible for a high percentage of peptic ulcers. A survey of the

of the peptic ulcer problem, that once peptic ulcer attains the behavior of a perforating ulcer it will remain such during

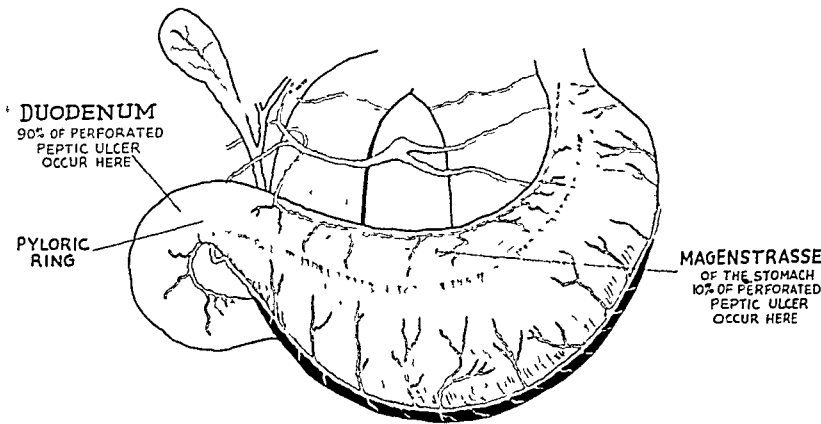


FIG. 1. Diagram of stomach and first portion of duodenum with circulation.

personal cases revealed that 80 per cent have graded infections of the mouth ranging from a moderate degree of gum irritation to advanced pyorrhea alveolaris.

Heritage or family predisposition for peptic ulcer development may hold true in the perforated type of ulcer as in many other diseases. We found some indications that when one member of a family is affected with perforated peptic ulcer, all members of the same family affected with peptic ulcers will have symptoms of the perforative type or may go to actual perforation. Such an incidence was found in the group of personal cases. Two brothers had acute perforated duodenal ulcers. Records show the perforations were eighteen months apart. Both were operated upon within six to eight hours after inception of perforation, with recovery. We are informed that a third brother succumbed to operation for perforated peptic ulcer three years later. This is interesting evidence, but, of course, not conclusive.

The majority of acute peptic ulcers heal quickly and completely. From the clinical and x-ray evidence it appears that an ulcer may heal, recur, break down and heal again, the ulcer becoming deeper and more fibrotic with each recurrence. We believe, and such opinion is based on a careful study

its period of existence. Healing of such ulcer is interfered with in the following ways: (1) the irritative effect of the acid gastric juice; (2) the necrotic layer on the base of the ulcer which covers the granulating tissue and provides no footing for the ingrowing epithelium, and (3) the dense scar tissue which prevents the approximation of the edges.

#### SYMPTOMS

The symptoms of acute perforation, as so aptly set forth by Graham,<sup>4</sup> are (1) the upper abdominal rigidity, (2) pain in this area associated with tenderness, and (3) inability to turn from side to side in bed because of accentuation of pain.

In this subacute type of perforation the pain is not as a rule as excruciating nor is the prostration as profound as in that associated with acute perforation. Early examination reveals, however, the same board-like rigidity and marked upper abdominal tenderness. Within two to ten hours after the perforation has occurred the symptoms may have subsided and the patient may be fairly comfortable. If the patient is seen for the first time in this quiescent period, and especially if an opiate has been administered, the presence of the abdominal catastrophe may not be

suspected. The degree of local peritoneal irritation and disability is dependent upon the amount of gastric and duodenal content that has escaped. Local peritonitis and subphrenic and perigastric abscesses are not uncommon. They may be the origin of many cryptogenic, hepatic and subphrenic abscesses and external perigastric adhesions. Those cases in which the ulcer heals cause no further trouble and leave little, if any, evidence of the former existence of ulcers.

Chronic perforation occurs in 25 per cent of the cases of chronic peptic ulcer, and in 3.5 per cent of gastric carcinomas that are surgically verified. If the pain is of a continued boring nature, if the usual mode of obtaining relief is ineffectual, if the so-called pain-food-ease sequence is less distinctive, and especially if the originally localized pain extends toward the region of the liver posteriorly, or upward into the chest—or in the case of the jejunal ulcer downward toward the pelvis—the possible presence of a deep penetration or slow perforation should be seriously considered.

#### DIAGNOSIS

Other abdominal catastrophes which must be considered in any differential diagnosis of perforated ulcer are acute hemorrhagic pancreatitis, gallbladder disease, appendicitis, ruptured ectopic pregnancy, volvulus of stomach or omentum and abdominal crisis in tabes. Extra-abdominal lesions which must be considered are pleurodynia, lobar pneumonia, measles, arachnodism, herpes Zoster and coronary occlusion. The presence of the associated signs characteristic of these conditions plus a careful history usually establishes the diagnosis.

#### TREATMENT

The treatment is essentially surgical with operation as soon after perforation as possible. A prime consideration, we believe, based on personal experience, is that an opiate should be withheld until diagnosis has been definitely made and surgery

scheduled. We recall a specific case in which there was an associated heart condition to which an opiate was administered. The symptoms were masked so that the patient was judged improved, sent home five days after admission to the hospital, and expired there on or about the tenth day. Autopsy revealed a perforated gastric ulcer with generalized peritonitis, left subphrenic abscess, left pelvic abscess and moderate spill along the left colon gutter. Furthermore, disturbing diagnostic procedures such as fluoroscopy should be avoided, for they not only consume time, but aggravate an abdomen which should be kept at rest. We do favor, however, a flat x-ray plate of the abdomen immediately on admission to the hospital, with the patient in standing or sitting posture, for possible detection of air under the diaphragm, which is considered pathognomonic of a perforated viscus in these cases.

Preoperatively, intravenous fluids should be administered to combat dehydration and impending shock. Nothing, of course, should be given by mouth. If immediate operation has been decided on, a hypodermic or morphine gr.  $\frac{1}{4}$  and atrophine gr.  $\frac{1}{100}$  should be given.

#### ACUTE PERFORATED DUODENAL ULCER

Acute perforated peptic ulcer occurs in the duodenum in 90 per cent of the cases. (Fig. 2.) The simple closure of the ulcer with interrupted sutures, incorporating a fold or graft of omental tissue, is the operation most often employed. There are certain essentials in this type of closure that should be stressed to obviate leakage and maintain the proper circulation in the involved tissues. The sutures are placed in the bowel wall a sufficient distance from the ulcer-bearing tissue to assure security of the suture. In the approximation of the omental tissue to the ulcer bed in tying the sutures only sufficient tension should be made to hold the graft in place. Avoid constriction of the tissues that may interfere with their viability. The fibrin deposit as a result of the contact of the tissues will

seal the ulcer. In the hands of the average operator, this type of closure will maintain the lowest operative mortality. Many of

began to alter our simple closure to pyloroplasty in a certain selected group of cases. As a result of this type of therapy our

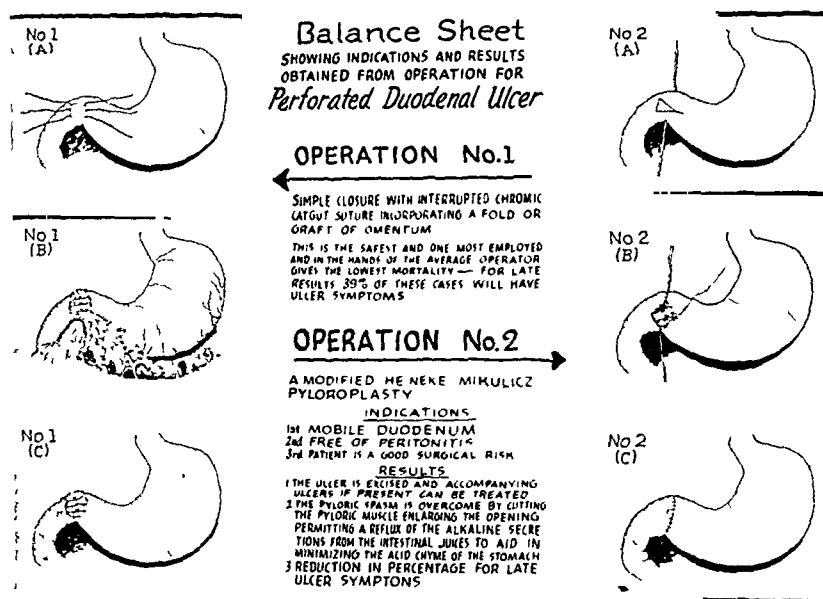


FIG. 2. Type of operations for perforated duodenal ulcer.

the writers in dealing with the perforated duodenal ulcer stress the simple closure for the reason that acute perforation is an emergency problem and anything beyond closure of the ulcer is meddlesome surgery.

Statistics show approximately 39 per cent of the patients who have had simple closure continue to have ulcer symptoms. Aside from the delayed digestive complaints a small percentage of the duodenal ulcers treated in this manner will re-perforate. During a five-year period Graham<sup>5</sup> reported fifty-one cases of acute perforated duodenal ulcer in which the patients were operated upon by the simple closure with omental graft. Of these, 11 patients or 21+ per cent continued to have digestive complaints, requiring elective surgery in the form of gastric resection, pyloroplasty or gastroenterostomy.

For a number of years we employed the simple closure incorporating omental tissue exclusively with practically the same results. After due consideration through close observation relative to re-perforation and the high percentage of patients who continued to have digestive complaints, we

mortality has remained as low or lower than that observed from simple closure. The delayed digestive complaints have been reduced to less than 10 per cent with reduction in number of re-perforations. We have found pyloroplasty offers the maximum results in the cases which reveal the following characteristics: (a) the duodenum is mobile; (b) peritonitis is not present; (c) patient is a good surgical risk; (d) induration at ulcer area is such that removal of the ulcer will not sacrifice so much tissue as to interfere with proper closure of opening in bowel and stomach.

By pyloroplasty an ulcer is excised and oftentimes an accompanying ulcer may be found on the opposite side of bowel, commonly called "contact or kissing ulcer," which can be treated by cautery. The spasm of the pylorus is overcome by cutting the pyloric muscle; the ulcer is excised in a combined rectangular-elliptical incision going well on to the stomach; the closure of opening in the bowel and stomach is in a transverse manner. (This is a modification of the Heineke-Mikulicz pyloroplasty.) As a result of such closure the

pyloric opening is enlarged, permitting a free reflux of the alkaline secretions from the bile, pancreatic and intestinal juices on the stomach mucosa to reduce the acidity of the chyme.

Posterior gastroenterostomy at the time of closure of ulcer should be avoided for two reasons: (1) The edema present at the pyloric ring at the time of perforation in the majority of cases rapidly subsides following closure of the ulcer sufficiently to secure free drainage of the stomach; (2) the gastric juice in perforated ulcer usually shows a higher percentage of free hydrochloric acid than is normally present. This hyperchlorhydria with its constant bathing of the new stoma frequently leads to the formation of marginal jejunal ulcer. However, in definite obstruction of the pylorus resulting from the duodenal ulcer with perforation, or in the chronic perforated ulcer, posterior gastrojejunostomy may be indicated.

#### ACUTE PERFORATED ULCER IN THE STOMACH

In our series of cases 10 per cent of the perforations occurred in the stomach. The relationship of the ulcer formation in the stomach to the Magenstrasse area and the tendency for such ulcers in proximity to the pylorus to undergo malignant changes has been discussed.

The surgical management of the perforated ulcer occurring on the anterior wall of the stomach is usually accomplished by a simple closure with an omental graft. Should the ulcer present evidence of malignancy, biopsy should be made at the time of closure.

Perforated ulcers on the posterior wall of the stomach behave differently from those seen on the anterior wall. Normally, the posterior wall of the stomach is in close proximity to the pancreas and posterior peritoneum.

When the ulcer becomes inflamed or perforated, protective adhesions are formed at the ulcer bed. In a certain percentage of these cases the formation of the adhesions

will prevent a spill of the stomach content into the peritoneal cavity.

Due to the localization of the infection the ulcer often acquires the characteristics of a subacute ulcer.

In case the ulcer is near the lesser curvature of the stomach and lacks the protection of adhesions, or when the crater of the ulcer is of such size that the adhesions do not prevent the spill following perforation, peritonitis results. The surgical repair for the perforated ulcer on the posterior wall of the stomach is rendered difficult and closure is seldom attempted due to the position, inflammatory adhesions and inability to secure good closure of the ulcer. Management demands some form of gastric resection, depending on the condition of the patient, and the inflammatory changes that have taken place about the ulcer. If the case is one in which the general condition of the patient is good and the adhesions and inflammatory changes are not extensive, a one-stage resection of the stomach with a posterior gastrojejunostomy by the Polyá II type operation or Hofmeister subtotal gastrectomy with gastrojejunal anastomosis will be indicated.

Should the patient show evidence of toxemia and low reserve, accompanied by dense adhesions at the point of perforation and evidence of a recent spill, a two-stage resection with a posterior gastrojejunostomy should be done, as advocated by Devine.<sup>6</sup> At the first-stage operation the stomach should be bisected proximal to the ulcer bed, leaving sufficient tissue on the blind end of the stomach to secure a good closure. After closing the lower end of the stomach where the ulcer is located, the proximal resected end should be closed from the lesser curvature down to a point leaving sufficient opening to make an adequate gastrojejunal stoma by an end-to-side posterior gastrojejunostomy. If the spill of the ulcer bed is sufficient to encourage peritonitis, a penrose drain should be placed down to the ulcer bed. At a subsequent date when the patient's condition will permit—and this will usually



require two to three weeks—the blind end of the stomach containing the ulcer is removed, including the pylorus with closure of the duodenal stump.

#### REPORT OF CASE TO ILLUSTRATE EFFICACY OF THE TWO-STAGE RESECTION

A white male, fifty-six years of age, entered the hospital on April 11, 1941. He gave a history of stomach trouble for several years. In February, 1941, the so-called food-ease sequence was replaced by a progressive boring pain in the left upper abdomen, aggravated by taking food, accompanied by nausea and vomiting, with loss of eighteen pounds in weight in two months. A large fixed mass was found in the left upper abdomen. Urine examination was negative. Blood picture was that of secondary anemia. The white blood count was 16,700 cells per cm. of blood with 80 per cent neutrophiles; the remainder of white cells were normal. Gastric analysis was 24 free hydrochloric acid and 42 total acids.

X-ray of stomach showed  $33\frac{1}{3}$  per cent retention of the six-hour barium meal and defect in midportion of stomach. Operation on April 19, 1941, was performed with spinal anesthesia. The abdomen was explored through an upper rectus incision, which disclosed a large inflammatory tumor, measuring 10 by 12 cm. in diameter at the base. Incorporated in the tumor mass were stomach, pancreas and posterior peritoneal wall, caused by perforated ulcer on the posterior wall of the stomach. Along the lower margin of mass peritonitis was present, resulting from spill of the ulcer. Obviously a subtotal resection of the stomach was indicated. Due to the inflammatory changes and recent spill from the ulcer, a two-stage antral exclusion resection of the stomach with a retrocolic end-to-side gastrojejunostomy by the Polyá II type operation with closure of the blind end of the stomach was done. A penrose drain was placed at the point of perforation of the ulcer to care for the peritonitis.

The convalescence was a smooth one. The patient left the hospital in two weeks, to return two weeks later for the second operation, when the blind end of the stomach including the pylorus was removed with closure of the duodenal stump and peritonealization of the raw tissues at the bed of the stomach. Convalescence was again uninterrupted. By the

multiple-stage operation the patient was carried through surgery with a minimum shock and the elimination of the technical difficulties and complications.

#### JEJUNAL ULCER PERFORATION

There were two cases of jejunal ulcer in our series. Of these two, one patient went to surgery and the ulcer was not found until autopsy. The other patient was not operated upon, as he was in extremis when admitted to the hospital and died the next day. Autopsy revealed perforated ulcer with peritonitis. Jejunal ulcers occur on the efferent loop of the bowel and the majority are perforating in character. History of return of digestive complaints, after apparent cure of duodenal or gastric ulcer following gastroenterostomy, pain in the left abdomen, not relieved by taking food and appearance of melena stools indicate a jejunal ulcer. Treatment resolves into excision of the stoma, closing the opening in jejunum in transverse manner, or a resection of the loop bowel with end-to-end anastomosis if the ulcer crater involves too much of the bowel wall. The opening in the stomach should be closed to allow the stomach to drain by the duodenal route provided the pylorus is patulous and the duodenal ulcer is healed. If obstruction of the pylorus is found or activation of the ulcer is present, partial resection of the stomach by the Billroth I type operation gives the best results.

Drainage should be done only in those cases of perforated peptic ulcer in which definite peritonitis is present or several hours have elapsed before surgery and there is unusual amount of spill of undigested food from the perforated viscus. In the case in which intraperitoneal drainage has not been provided, to avoid wound infection, place a rubber tissue drain down to the peritoneum, especially in the obese type individual; this will reduce the number of abdominal wall infections.

We believe spinal anesthesia for the patient with a perforated peptic ulcer gives the best results, affording a better relaxa-

tion of the abdominal wall and the peritoneal tissues, thus giving an opportunity for ample exposure. This tends to minimize the time of operation and also reduces the postoperative chest complications which are frequently seen in inhalation anesthesia in upper abdominal surgery.

#### CONCLUSION

From the analysis of this series of cases the following conclusions were drawn:

1. Ninety per cent of the perforated peptic ulcers are located within 2 cm. of the pylorus on the anterior surface of the duodenum.

2. Duodenal ulcers tend to perforate in this area because of the poor blood supply, constant bathing of the ulcer with acid gastric juice and lack of any anterior protective covering.

3. On the basis of late results following simple closure with omental graft this type of operative therapy might be altered to a pyloroplasty when the time interval of

perforation has been only a few hours, provided peritonitis is absent, the duodenum is mobile and the patient is a good surgical risk.

4. Posterior gastrojejunostomy should be done only in the obstructive or chronic perforative and not in the acute perforated type.

5. By surgical intervention as soon as possible our mortality has been decreased to 18.5 per cent in the 116 operative cases in this total series of 124 cases.

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# CARCINOMA OF BODY AND TAIL OF PANCREAS\*

## A CLINICAL AND PATHOLOGICAL ENTITY

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**A**CCUMULATING reports in medical literature, as well as our observations upon twenty-six instances of pancreatic carcinoma encountered in 3,500 autopsies, have impressed us with the importance of carcinoma of the body and tail of the pancreas. We believe that malignancy in the body and tail deserves greater consideration than is usually given in the differential diagnosis of pancreatic malignancy. Such consideration is merited because of the frequency, the suggestive clinical picture and the fact that the pathological condition differs from that of lesions in the head of the organ.

### FREQUENCY

The frequency of carcinoma of the body and the tail of the pancreas is not appreciated. Bard and Pic's<sup>1</sup> description in 1888 of the clinical syndrome of carcinoma of the head is familiar, but it is not generally realized that carcinoma of the body and tail is about one-third as frequent. Duff<sup>2</sup> recently compiled 1,108 cases of pancreatic carcinoma from the literature and added fifty cases encountered in the first 14,000 autopsies at Johns Hopkins. In the series 596 were in the head, 166 in the body or tail or both, 186 in the whole pancreas, while 230 were in undetermined or unrecorded locations. Duff was able to study the clinical and pathological records of sixteen examples of the body and tail. Ransom,<sup>3</sup> at Ann Arbor in 1935, studied sixteen similar cases.

Lack of interest or appreciation of carcinoma of the body and tail as an entity to be distinguished from carcinoma of the

head is reflected in medical literature. During the years 1931 to 1940 inclusive 163 articles on carcinoma of the pancreas are listed in the Index Medicus. In this number 111 discuss simply carcinoma of the pancreas, thirty-three carcinoma of the head, while only seven are concerned with cancer of the body and six deal with cancer of the tail and cancer of the body and tail.

Medical and surgical texts commonly have emphasized carcinoma of the head of the pancreas when discussing malignancy of this organ. Lesions of the body and tail have been treated as rare or unimportant. Usually the statement is made that carcinoma of the head is the most frequent lesion and then the symptoms of that lesion are elaborated.

In the 1933 edition<sup>4</sup> of a widely used Textbook of Medicine, and again in the 1940 edition,<sup>5</sup> we read "carcinoma usually occurs in the head of the organ and rapidly involves the bile-duct and adjacent lymph nodes. . . . The symptoms vary with the location of the tumor, but great weakness, loss of weight, and extreme anorexia are always present. . . . The pain and tenderness vary with the amount of involvement of the celiac plexus. The pain is characteristically of a severe, boring or grinding type and extends through to the back." No attempt is made to point out the clinical picture characteristic of carcinoma of the body or tail.

In the 1936 and 1939 editions<sup>6,7</sup> of a widely used Textbook of Surgery we find: "primary carcinoma of the head of the pancreas is by far the most frequent. . . . The symptoms of cancer of the pancreas

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are dependent on compression of nerves, blood vessels and bile ducts and on the interference with the digestive function. . . . Jaundice appears early because of the fact that the common duct which passes through or beneath the head of the pancreas, is so easily compressed. . . . It is usually the first symptom which sends the patient to his physician. Pain is a symptom of importance and is usually colicky at first. . . . Later it becomes dull and constant and is referred to the back." The symptoms—jaundice and pain—and tumor and x-ray findings are discussed, but no distinct clinical picture of cancer of the body and tail is presented.

In the differential diagnosis chronic pancreatitis is considered of great importance, but no effort is made to differentiate the site of any existing carcinoma.

As a result of this emphasis upon carcinoma of the head, most students and practitioners think that the lesion occurs almost exclusively in that region. We have repeatedly questioned senior students about cancer of the pancreas and invariably they describe the clinical syndrome indicating involvement of the head.

It would seem that the frequency of cancer of the body and tail, one-third that of cancer of the head, would entitle it to more emphasis in teaching and medical writing. If it is possible to distinguish between the two, the methods for so doing should be taught.

#### CLINICAL CHARACTERISTICS

That carcinoma of the body and tail does present a suggestive clinical picture has been well established. It was first pointed out in 1908 by Chauffard<sup>8</sup> who reported three cases with severe pain, rapid and severe emaciation and absence of jaundice. The pain was epigastric, sudden in onset, beginning on the left but soon generalizing over the abdomen and radiating to the back, chest or scapulae, and unrelated to food. The pain resembled that of tabetic crises, while nausea and vomiting were unimportant. Chauffard's observations did

not evoke a great deal of interest, nor did subsequent contributions by Leriche<sup>9</sup> and Malus.<sup>10</sup> Two excellent recent articles, by Ransom<sup>3</sup> and Duff,<sup>2</sup> deal with the subject.

Ransom's studies confirmed the clinical picture originally described by Chauffard. Abdominal pain was the chief complaint in thirteen of sixteen cases. In Duff's series abdominal pain was present in fifteen of the sixteen cases, in fourteen as an initial symptom. The pain was dull, aching or boring or paroxysmal, most frequently epigastric and radiating to the left. The last feature was the only striking characteristic of the pain and neither Duff nor Ransom could find a constant type or location for the pain common to a majority.

In our own series of twenty-six cases of carcinoma of the pancreas, with eight confined to the body and tail, pain was an outstanding symptom in twenty-one cases. The clinical records indicate that the pain was most frequently found in the upper portion of the abdomen, but it was equally divided between right and left upper quadrants, with no apparent relation between the location of the pain and the site of the growth in the pancreas.

The clinical records in our eight cases of carcinoma of the body and tail conform to the picture first described by Chauffard and later by Ransom and Duff. Pain and emaciation were present. Jaundice developed in only one patient, late in the course.

Analysis of the eight case records shows that pain was the presenting symptom in six. The pain was epigastric in two, while it was located low in the back, to the right of the umbilicus, in the left upper quadrant, or diffuse in one each. The pain was described as dull in one case, stabbing in one, gas pain in one, colicky in one and attacks of pain in two. Weight loss was recorded in three of the eight cases. Nausea and vomiting were present in four. The duration of symptoms in seven of our cases varied from two to six months. In the eighth case the history was unreliable; apparently malignancy intervened in a cystadenoma, possibly two years before

death. Six of the group were males, varying from seventy-eight down to eighteen years in age. The ages of the females were sixty-five and thirty-four years. The average age was 53.7. In four instances an abdominal mass could be felt.

Duff listed misleading signs and symptoms in carcinoma of the body and tail in addition to the above typical findings. In the group were hematemesis, blood in the stools, distended abdominal veins, palpable spleen and liver and jaundice. The clinical records in our eight cases revealed constipation in three, ascites in five, eructations of gas in three and enlarged liver in two.

The features of carcinoma of the body and tail of the pancreas as an entity presenting a clinical picture for definite diagnosis were clearly set forth by Cabot<sup>11</sup> in 1938, as follows: "the early symptoms are too vague to direct attention to the pancreas. Late symptoms depend upon the part of the organ involved. Cancer of the head of the pancreas causes obstruction of the common duct, producing intense, progressive jaundice, usually without pain, and accompanied by enlargement of the liver and gall bladder. Cancer of the body or tail of the pancreas produces constant, severe boring pain in the back; if the body is involved, the pain is in the mid-back at the level of the 12th thoracic or 1st lumbar vertebra; if the lesion is in the tail, the pain is felt in the left costovertebral region or slightly higher. Jaundice and liver enlargement are not present, since the common duct is not obstructed."

It would be justifiable, therefore, strongly to suspect carcinoma of the body or tail of the pancreas when the following clinical syndrome is present: (1) A male usually above forty years of age develops upper abdominal pain which may be epigastric or in either upper quadrant, radiating to the left back, chest or scapulae, often paroxysmal or deep and boring in the back; (2) loss of weight and strength, usually within a few months; (3) absence of jaundice or mild jaundice developing late in the dis-

ease; (4) the absence of positive findings indicating specific lesions of other abdominal viscera, often coupled with the presence of one or more confusing symptoms such as constipation, hematemesis, blood in the stools, distended abdominal veins, palpable spleen or liver, eructations of gas and ascites; and (5) the presence of a mass in the midepigastrium or either upper quadrant.

#### DIFFERENTIATION FROM CANCER OF THE HEAD OF PANCREAS

We have for years been impressed by the massiveness of metastases in cases of carcinoma of the body and tail, and with their paucity in cancer of the head. This fact is not emphasized in clinical texts, however. A knowledge of the difference in dissemination in the two types is important in differential diagnosis and in the consideration of operative procedures.

One should know the biological behavior of carcinoma of the different sites in the pancreas in attempting a differential diagnosis. The presence of massive metastases speaks against a primary tumor of the head. Duff, in sixteen cases of cancer of the head, found four with no metastases, nine in which the metastases had not spread beyond regional nodes and liver, and only two with widely distributed metastases. He points out that carcinoma of the body and tail, on the other hand, metastasizes widely and massively. In sixteen such cases only one was free from metastases, two had metastases limited to regional nodes and liver, while in the remaining thirteen metastases had spread beyond these limits. In our eight cases arising in the body and tail, one had no metastases, two had regional node and liver involvement and five had more extensive metastases.

The operating surgeon considering radical resection of a pancreatic tumor should know the probabilities and types of metastases. Recently, Crile<sup>12</sup> reported successful radical resection of a highly differentiated carcinoma of the head with no regional metastases. Eight autopsies at the Cleve-

land clinic on patients dying after exploratory or palliative operations for carcinoma of the head showed that in six the tumor was limited to the resectable area. With such knowledge a surgeon can offer some patients a chance for permanent cure.

In addition to the massiveness of the metastases, Duff points out that cancer of the body and tail tends to spread more widely than that of the head. The anatomical position and relations of the body and tail favor extension to the surface of the organ, with easy widespread peritoneal implantation or penetration of transverse colon, stomach or diaphragm. Extension via lymphatics occurs widely, possibly through the lymphatics of tissues directly invaded. Direct growth into large tributaries of the portal vein, with the production of thromboses, probably favors transport of tumor cells to the liver, with abundant opportunity for massive growth.

Massive and widespread metastases to peritoneum, retroperitoneal nodes, and liver, as well as direct extension into the transverse colon, stomach, diaphragm, and large veins, often with obstruction of large intrahepatic branches of the portal vein, help to distinguish carcinoma of the body and tail from cancer of the head. These features serve adequately to explain the clinical picture and the occasional misleading symptoms.

#### CASE REPORTS

The following case histories serve to exemplify some of the features mentioned above and add eight more cases to the literature:

**CASE I. (R153-30).** Mr. E. G., a fifty year old laborer, was admitted to the Creighton Memorial St. Joseph's Hospital August 29, 1930 because of abdominal pain and vomiting for seven days. Six weeks before he had become ill with chills, fever, nausea, vomiting and diarrhea for ten days and was in a hospital for what was diagnosed as typhoid fever. He left the hospital only a week before admission to St. Joseph's Hospital.

Physical examination revealed coarse râles

over the lower lobes of the lungs, a mass in the abdomen just below and to the left of the xiphoid, irregular fixed pupils, a positive Rhomberg, exaggerated knee jerks and areas of anesthesia over the feet and legs.

The urine contained a trace of albumen. The gastric juice contained no free acid and the total acids were 7. There was a secondary anemia. The blood Wassermann was positive. The Widal test was negative, as were blood cultures. The spinal fluid Wassermann was positive and the spinal fluid cell count 6. X-rays revealed an irregularity in the upper one-third of the stomach, apparently due to pressure from behind. There was considerable irregularity in the upper stomach border and the radiologist concluded that there was a new growth in the cardiac end of the stomach. Proctoscopic examination revealed a relaxed sphincter and the anterior wall of the rectum was boggy.

The temperature varied from 100 to 105°F. and on September 15, 1930 there was some rigidity in the left upper quadrant. He became comatose and died on September 22.

**Anatomic Diagnosis:** Carcinoma of the tail of the pancreas with metastases to spleen, liver, retroperitoneal lymph-nodes; splenomegaly; syphilitic aortitis.

**Autopsy Findings:** "There is a large firm mass involving the tail of the pancreas and adherent to the hilum of the spleen; this mass cuts with increased resistance and on section is quite firm and gray. It is 7 × 5 × 2 cm. In the middle of the pancreas there are 2 spherical nodules, each about 1 cm. in diameter, which on section are white with yellow spots throughout. In the head of the pancreas there are other smaller nodules. The spleen is 4 times normal size; on section it is soft and the pulp is filled with small, white masses. The liver weighs 1700 grams and contains small confluent nodules forming a mass 2 cm. in diameter on the upper surface of the right lobe." Microscopic examination confirmed the diagnosis of carcinoma of the tail of the pancreas with metastases.

This case illustrates pain in the upper abdomen, a rapid down-hill course, the absence of jaundice and metastases to the lymph-nodes, spleen and liver.

**CASE II. (R1625).** A seventy-eight year old retired business man was admitted to

the Creighton Memorial St. Joseph's Hospital February 13, 1933 for low back pains. He had fallen on the icy pavement two months before. The pain had been getting worse. He had suffered from constipation for forty years and occasionally passed blood in the stool, the last time about a year ago. He had a hemorrhoidectomy in the same hospital three years before.

Physical examination revealed only the changes of senility. The laboratory findings were normal. The stool contained no blood. X-rays revealed no definite pathological condition in the gastrointestinal tract. He was discharged with a diagnosis of chronic constipation and chronic arthritis.

He was readmitted on March 3, 1933 because of the persistence of pain, mostly over the right iliac crest, constant and preventing sleep. He did not think he had lost any weight. X-ray of the spine and pelvis revealed a marked osteoarthritis. A barium enema showed a narrowing in the rectal lumen, due to muscular contraction. Injection of air after the expulsion of the barium failed to reveal any definite pathologic change in the rectosigmoid area. Attempts to pass a proctoscope beyond the rectosigmoid junction produced considerable pain and digital examination of the rectum revealed a mass the size of a hen's egg on the anterior wall of the rectum above the prostate. He left the hospital the following day with a diagnosis of metastatic malignancy involving the rectosigmoid region. He died at home on March 13, 1933.

*Anatomic Diagnosis:* Carcinoma in the tail and body of the pancreas with extension into the head; metastases to the liver and mesenteric lymph-nodes and to the peritoneum over the rectosigmoid junction.

*Autopsy Findings:* "The pancreas is large and nodular and on section contains nodular tumor masses. These are most marked and largest in the tail, although there are small nodules in the head. The liver is dotted throughout with white raised areas, measuring 1 to 3 cm. On section these areas are white and homogeneous. In the mesentery there are numerous, hard, large discrete masses which on section are gray to white and resemble the masses in the liver. At the junction of the descending colon and sigmoid, which is long and redundant, there is a rather hard fibrous mass binding the bowel to the abdominal wall;

this mass tears with ease and the torn edges are evidently malignant tumor tissue. A similar picture is seen in front of the rectum just above the prostate, where the rectal wall is constricted and compressed, but the tumor mass here only involves the peritoneal surface."

Microscopic examination revealed carcinoma arising in the tail of the pancreas.

This case illustrates the confusing symptoms due to peritoneal metastases, as well as the massive liver metastases and the absence of jaundice.

CASE III. (R1771). An eighteen year old laborer was admitted to the Creighton Memorial, St. Joseph's Hospital December 18, 1933, for loss of weight and strength, coupled with nausea and vomiting over a five-month period. At the onset of the illness he had an occasional heartburn. In the past month he vomited practically all food eaten. The vomiting occurred from one-half to two hours after ingestion of food and later contained bile and fecal material. He had lost sixteen pounds in weight.

Physical examination revealed upper right rectus muscle rigidity persisting even after sodium amytal hypnosis. It was doubtful whether a small mass could be felt in the upper right quadrant. The urine contained six to eight pus cells per high power field. The leukocyte count was 20,800.

Exploratory laparotomy on December 19, 1933 for probable intestinal obstruction revealed extensive secondary carcinoma of the liver, with a primary growth in the tail of the pancreas. He died December 29, 1933.

*Anatomic Diagnosis:* Carcinoma of the tail of the pancreas, with metastases to liver and regional lymph-nodes; passive hyperemia of abdominal viscera; recent right rectus surgical incision; chronic rheumatic carditis with fibrous pericarditis and verrucous mitral endocarditis.

*Autopsy Findings:* "The tail of the pancreas is enlarged, nodular, gray and granular on section. The liver extends 2 fingers below the right costal margin and well over to the left. Its entire surface is covered with white, circumscribed umbilicated nodules, ranging from 1 to 4 cm. in diameter. On section these nodules range from gray to white, are granular and essentially like the nodules in the tail of the pancreas. The peripancreatic nodes are

likewise enlarged and replaced by similar tumor tissue."

Microscopic examination revealed adenocarcinoma, grade IV, primary in the tail of the pancreas.

This case exemplifies the rapid weight loss, the massive metastases and the complete absence of jaundice commonly encountered in carcinoma of the body and tail. The tumor was remarkable in that it occurred in an eighteen year old boy. In Ransom's series the youngest patient was forty and the average age 57. In Duff's series one case was encountered in the second decade and the average age was 51.2.

CASE IV. (R2322). Mr. E. D. J., a sixty-three year old barber, was admitted March 29, 1936 for stabbing pain in the epigastrium of six months' duration. He had had orthopnea for the same period and had been under treatment for heart disease. He had had occasional nausea and vomiting, gradual increase in the size of the abdomen, anorexia and a thirty pound weight loss. Three years ago he had a transurethral prostatic resection.

Physical examination revealed a blood pressure of 164/94, beginning bilateral pterygium, imbedded fibrosed tonsils with injected pillars and cervical adenopathy, mucous râles over both lung bases, a heart enlarged to the left and downward, an apical systolic murmur, ascites, and a tender lower liver border. The left saphenous vein was thrombosed. There were one plus albuminuria and cylinduria. The white cells of the blood numbered 19,450, with 90 per cent neutrophile polymorphonuclears. X-ray studies suggested intra-abdominal adhesions with no demonstrable obstruction.

On April 12, 1936, with a preoperative diagnosis of chronic intestinal obstruction, operation revealed extensive intra-abdominal malignancy. The primary growth was not identified. A jejunostomy was done and the patient died the next day.

*Anatomic Diagnosis:* Carcinoma of the tail of the pancreas with extension into the omentum, metastases to the liver and lung; generalized subacute peritonitis and ascites; bilateral pulmonary congestion and infarction of the right lung base; hypertrophied left cardiac

ventricle; sclerotic thickening of aortic cusp of the mitral; atherosclerosis of the aorta.

*Autopsy Findings:* "The peritoneum is markedly thickened and dotted with small white patches. The mesenteric fat is nodular. All the abdominal organs are matted down and adherent to the surrounding structures. In the tail of the pancreas there is a large tumor mass measuring 6 × 4 cm., white and homogeneous on section. The liver weighs 1700 grams, and over its surface are many white nodules varying in size from 2 mm. to 2 cm. On section these nodules are present throughout the liver substance." Microscopic examination revealed adenocarcinoma of the tail of the pancreas with metastases.

This case illustrates the presence of stabbing pain in the epigastrium, ascites, extensive metastases to the liver, and the absence of jaundice.

CASE V. (R2406). Mr. A. A., a sixty-seven year old farmer, was admitted to the Creighton Memorial St. Joseph's Hospital July 22, 1936, because of pain in the left upper quadrant for four months. During that time he had attacks of pain, accumulations of gas, belching and nausea, coming on three to four hours after meals and during the night. The attacks lasted about thirty minutes. He seemed to get relief by eating small amounts and taking a glass of milk. The type of food seemed unimportant. His appetite was good. He was somewhat constipated.

Physical examination revealed a thin asthenic male. The tonsils were enlarged. The abdomen was soft and the wall relaxed, while there was no tenderness or rigidity and no masses were felt.

A clinical diagnosis of gastric ulcer was made and he was treated accordingly. He continued to have discomfort. On August 3, 1936, he developed fears of impending death and gradually became weaker. On August 29, 1936, he became delirious and noisy. He died on September 1, 1936. A final clinical diagnosis of gastric ulcer, dehydration and psychosis was made.

*Anatomic Diagnosis:* Carcinoma of the tail of the pancreas with no metastases; emaciation and dehydration; cardiac failure with pulmonary edema; chronic gastritis and chronic catarrhal enteritis.



*Autopsy Findings:* "A hard nodule measuring  $10 \times 5$  cm. is present in the tail of the pancreas. On section it is gray and solid. . . . No metastases." Microscopic examination showed this to be a scirrhus carcinoma of the tail of the pancreas without metastases.

This case illustrates the clinical syndrome of attacks of pain, weight loss with nausea, and no jaundice. It failed to metastasize widely, however, and is the only one in our series without metastases.

CASE VI. (R2548). Mr. W. W., a fifty-five year old rancher, was admitted to the Creighton Memorial St. Joseph's Hospital complaining of pain in the right umbilical region for five months and weight loss for three months. The pain seemed to date from an accident and a fall with severe muscle strain. A month after the accident he began to have gas pains in the abdomen, radiating up into the shoulder pits. He also began to lose weight and strength. An appendectomy was done, but he obtained no relief from the symptoms. He had required daily enemas because of constipation.

Physical examination revealed a slight limitation of movement of right lung, with a flat percussion note over the right base, as well as absence of vocal fremitus over that region. There was slight bulging of the abdomen to the right of the umbilicus; a mass was palpable in this region and in the right upper quadrant. There was flatness to dullness on percussion in the epigastrium and left upper quadrant. External and internal hemorrhoids were present and the prostate was somewhat enlarged.

On February 11, 1937 an exploratory laparotomy was done. There was found a small amount of fluid in the abdominal cavity. The liver contained many metastatic nodules. In the body of the pancreas there was a hard nodular mass. The final surgical diagnosis was "probable carcinoma of the pancreas with metastases to the liver." The pathological diagnosis on the material removed for diagnosis was "metastatic carcinoma of the abdominal wall and liver." He died on March 26, 1937.

*Anatomic Diagnosis:* Carcinoma of the tail of the pancreas with extensive metastases to the regional lymph-nodes, liver, peritoneum, diaphragm, chest wall and lungs.

*Autopsy Findings:* "In the tail of the pancreas there is a hard nodule measuring  $8 \times 6$

cm. On section it is white and firm with scattered yellow spots. All of the peripancreatic lymph nodes are enlarged and filled with tumor tissue. The largest mass is 3 cm. in diameter. The liver is greatly enlarged and filled with tumor nodules. The largest mass is 5 cm. in diameter. On section the entire right lobe of the liver is replaced by tumor tissue which is necrotic in the center. The liver, together with the pancreas, the tumor mass and the spleen, weigh 5 kilograms. Many adhesions between liver and diaphragm and the hepatic flexure of the colon and the diaphragm. Mesenteric nodes, large and white. Cecum bound to posterior peritoneum by several large tumor nodules, the largest 2 cm. in diameter."

Microscopic examination indicated grade III adenocarcinoma of the pancreas with widespread metastases to peritoneum, mesenteric lymph-nodes, liver and lungs.

This case illustrates the presence of pain, rather rapid weight loss, absence of jaundice, with the pathological findings of widespread massive metastases to peritoneum, lymph-nodes, liver, abdominal wall and chest wall.

CASE VII. (R2777). Miss E. Y., a sixty-five year old female, was admitted to the Creighton Memorial St. Joseph's Hospital January 4, 1938 complaining of epigastric pain for a period of two years. Nausea and vomiting accompanied the attacks of pain, while food only seemed to aggravate them. She had undergone treatment for colitis twelve years before in the same hospital.

Physical examination revealed slight epigastric tenderness and a mass in the left upper quadrant.

Exploratory laparotomy, with a preoperative diagnosis of splenomegaly, on January 13, 1938 revealed extensive carcinomatous involvement of the peritoneum and a large mass in the left upper abdomen involving the fundus of the stomach and the hepatic flexure of the colon. There were numerous metastases in the liver. The final surgical diagnosis was carcinoma, probably primary in stomach or colon. Biopsy of a mass in the omentum revealed grade IV carcinoma. She died January 15, 1938.

*Anatomic Diagnosis:* Massive carcinoma of the tail of the pancreas, with extensive necrosis of the tumor mass; extensive metastases to all

regional lymph-nodes, retroperitoneal lymph-nodes and liver; pressure deformity of the stomach and multiple erosions; varicose veins in the posterior wall of the stomach; massive adhesions in the upper abdomen.

*Autopsy Findings:* "The stomach, transverse colon and part of the ileum are bound together by adhesions. On the surface of the liver there are many umbilicated nodules. There are numerous adhesions about the pancreas, which contains an orange sized nodule in the tail. There are many varicose veins in the posterior wall of the stomach. . . . Retroperitoneal lymph nodes are markedly enlarged."

Microscopic examination showed the tumor to be grade iv carcinoma.

This case exemplifies recurring attacks of pain, widespread peritoneal, retroperitoneal and liver metastases, as well as absence of jaundice. Pressure upon the stomach and the presence of varicose veins, coupled with extensive adhesions in the upper portion of the abdomen, led to the erroneous diagnosis of primary involvement of stomach or colon.

CASE VIII. (R3480). Mrs. H. B., a thirty-four year old housewife, was admitted December 5, 1940 to St. Catherine's Hospital complaining of a mass in the left side for five years. She was somewhat incoherent and the history was obtained with difficulty. Five years before she had noticed a small mass in the left upper abdomen. At times the mass would almost disappear, only to enlarge again. About two years ago the mass become more prominent and had extended farther down on the left side and beyond the midline. There had been no pain, but only discomfort because of the size of the mass.

She was well nourished. The skin and sclerae had a slight yellow tinge. There was a large mass in the left upper quadrant, apparently the spleen. This mass was about the size of a football. Her speech was slow. She had a secondary anemia and a leukocytosis of 15,400 with 80 per cent neutrophils. There was a positive Malta fever agglutination test.

With a preoperative diagnosis of splenomegaly the abdomen was opened on January 21, 1941. There was found a large mass which seemed to be retroperitoneal and was possibly pancreatic in origin, with metastases to the

liver. Microscopically, one of the nodules removed from the liver was metastatic papillary carcinoma. The final diagnosis was made of intraabdominal carcinoma with metastases. She died on February 7, 1941.

*Anatomic Diagnosis:* Cystadenocarcinoma of the body of the pancreas with perforation into the stomach and widespread metastases to the liver, regional lymph-nodes, and retroperitoneal lymph-nodes; jaundice; ascites.

*Autopsy Findings:* "There are about 200 c.c. of straw colored fluid in the peritoneal cavity. There is a large cyst just below and attached to the lower border of the stomach and to the pancreas; it measures 20 cm. in diameter, is smooth and yellow and on section the cyst wall is quite thick. The cyst is multilocular, the compartments filled with yellow necrotic material and varying in size from 1 to 5 cm. The cyst wall has perforated through the posterior wall of the stomach into the gastric lumen and some of the same type of necrotic material is present within the stomach. The pancreas is adherent to the inferior surface of the stomach and the superior surface of the cyst. The common bile duct has not been obstructed. There are extensive metastases in the liver, the regional and retroperitoneal lymph nodes. The liver is enlarged to twice the normal size, contains many grey to yellow nodules and weighs 3200 grams. The spleen weighs 200 grams and there are some hyalinized plaques on the surface. The gall bladder is about twice normal size and contains 35 c.c. of black, concentrated bile."

Microscopic examination revealed a papillary cystadenocarcinoma of the pancreas with metastases.

This case illustrates a rather prolonged history with an adenocarcinoma arising in the body of the pancreas, the onset of jaundice only late in the disease, confusing symptoms leading to a diagnosis of splenomegaly, while the autopsy revealed massive metastases.

#### SUMMARY

Eight cases of carcinoma of the body and tail of the pancreas encountered in 3,500 autopsies have been reviewed.

Six of the eight cases were in men and the ages varied from seventy-eight down to

eighteen. Two were in women, aged thirty-four and sixty-five. The average age was 53.7 and one case was encountered in an eighteen year old boy.

Pain was the usual presenting symptom, in some instances occurring in attacks, but not constant enough in type or location to indicate the site of the growth.

An abdominal mass was felt in five patients.

The duration of symptoms before entering the hospital varied from two to six months in the seven cases in which the history was reliable.

Rapid weight loss was present in four cases.

Jaundice was absent in seven cases, and occurred late in one.

Carcinoma of the body and tail of the pancreas deserves more consideration when differential diagnosis of pancreatic lesions is considered. It occurs about one-third as frequently as carcinoma of the head. It presents a suggestive clinical picture with upper abdominal pain, weight loss, absence of jaundice, often the presence of a mass and confusing symptoms suggesting involvement of other intra-abdominal vis-

cera. The pathological findings reveal massive and widespread metastases compared to those of carcinoma of the head, explaining the confusing symptoms.

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# CHOLEDOCHOLITHIASIS\*

## A CLINICAL STUDY OF ONE HUNDRED NINE PATIENTS OPERATED UPON

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**D**URING the past twenty-five years we have witnessed a remarkable change in our concept of biliary surgery. Cholecystostomy as a procedure of choice gave way to cholecystectomy with the result that the patient subjected to operation was more likely to obtain a higher percentage of permanent relief. In the past, exploration of the common duct was rarely resorted to except in instances of persistent jaundice, or when the surgeon was able to palpate a stone in a dilated duct.

In recent years with a better understanding of the pathological physiology of gallbladder disease, careful follow-up of cases, and correlation with autopsy data, our attention has been focused on the pathological findings in the common duct, such as stones, inflammatory changes, interference with the function of the sphincter of Oddi, either by mechanical interference produced by stone at the ampulla of Vater, by stricture due to inflammation in the pancreas or by spasm secondary to disturbed physiology of the sphincteric mechanism.

The work of Lahey, Allen, Walters and others has stimulated surgeons to be more conscious of disease and pathological findings in the common duct. In spite of this there are many patients who have had gallbladder surgery and who still continue to have symptoms of biliary disease. A study of the cause and relief of symptoms following cholecystectomy has been carried out by Carter and Marraffino at the gallbladder clinic of the Postgraduate Hospital, New York City<sup>1</sup> 485 operative cases were investigated. Three hundred seven pa-

tients had a follow-up study. Of the above 307 patients there were recurrent symptoms in 193 patients (63 per cent). Eighty-four per cent of these 193 patients were treated medically and in the remaining 16 per cent secondary surgery was required.

*Pathological Physiology.* Histological studies of the extrahepatic ducts reveal that the muscular coats cease abruptly at the neck of the gallbladder, at the origin of the cystic duct. The ducts are fibro-elastic tubes lined with high columnar mucosa covered by a serosal layer, with the usual subserosal areolar tissue. Only small isolated fibers of unstripped muscle, sometimes indistinguishable from connective tissue cells, are found.<sup>2</sup> Large glands offer lodging to organisms metastatic from other foci of infection, and they may subsequently become responsible for a low grade cholangitis.<sup>3</sup> Nerve fibers are present in great abundance usually distributed in the outer parts of the wall.

Schrager and Ivy<sup>4</sup> have reported observations on the mechanical distention of the gallbladder and biliary passages in dogs. They found that distention of the gallbladder caused distress, inhibition of respiration, nausea and vomiting. Distention of the biliary ducts caused more striking symptoms than distention of the gallbladder alone. Zollinger<sup>5</sup> has shown that mechanical distention of the gallbladder in humans gave rise to deep epigastric discomfort, similar to the attacks of indigestion observed in gallbladder disease. Distention of the gallbladder did not cause vomiting. However, mechanical distention of the common duct did produce vomiting and severe epigastric distress. Walters<sup>6</sup>

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states that "generally speaking, infection, stone formation, and obstruction of the common duct can directly or indirectly be related to inflammation which has its origin in the gallbladder." Lahey<sup>7</sup> believes that gallbladder disease is a progressive disease at first limited to the gallbladder and as infection goes on gradually involves the duct system.

Stone formed in the gallbladder may pass through the cystic duct into the common duct. There it may remain as a silent stone or may become lodged at the ampulla of Vater, causing obstruction to the outflow of bile. Stone or other obstruction in the common duct is followed by dilatation of the duct or thickening of its wall. Dilatation of the common duct may also occur secondary to pancreatitis or to spasm at the sphincter of Oddi. Soft stones or débris may form in the common duct, secondary to obstruction of the duct by stones, pancreatitis or sphincteritis.<sup>8</sup>

The stone that had its origin in the gallbladder is usually hard, faceted and does not crush easily. The soft stones found in the common duct crush easily and are seldom faceted. Occasionally, both faceted and soft stones are found in the common duct. This may be explained by the fact that the faceted stone came down from the gallbladder, through the cystic duct, into the common duct and was lodged at the ampulla of Vater causing obstruction with secondary inflammatory changes. The soft stones have formed as a result of this obstruction and secondary inflammation in the common and hepatic ducts.

A sufficiently high pressure is maintained within the common duct to force the bile into the gallbladder where it is concentrated. Stimulation such as is produced by ingestion of food can cause contraction of the gallbladder and relaxation of the sphincter permitting flow of bile into the duodenum. A simultaneous contraction of the gallbladder and of the sphincter of Oddi produces increased pressure in the bile ducts.

The pain and distress that is produced by

such a phenomenon has been described as biliary dyskinesia. Best and Hicken<sup>9</sup> labeled this physiological obstruction of the common duct as "biliary dyssynergia." Many investigators have pointed out that cholecystectomy is followed by a marked and permanent loss of sphincter control. Doubilet and Colp<sup>10</sup> have shown that resistance of the common duct sphincter is about 100 mm. of water. When the gallbladder contracts, a pressure of 300 mm. of water is established. Magnesium sulfate, atropine, nitroglycerin, and amyl nitrite relax the sphincter. Morphine, stone in common duct, or hydrochloric acid produce spasm of the sphincter.

During the five-year period, from 1936 through 1940, 586 patients were operated upon at Mt. Sinai Hospital for biliary tract disease. In 477 cases, operations were confined to the gallbladder. In the remaining 109 cases, exploration of the common duct was performed, in addition to removal or drainage of the gallbladder. In the latter group, common duct stones were found in fifty-three cases, and débris was found in twelve cases. Sex incidence showed the usual preponderance of females (seventy-eight females and thirty-one males).

TABLE I

No. Operations	Died	Per Cent
586 on biliary tract.....	27	4.6
477 gallbladder alone.....	10	2.1
109 common duct, gallbladder and secondary operations.....	17	15.6
53 stones found in common duct.....	..	48.6
12 débris found in common duct.....	..	11.0
65 stones and débris.....	..	59.6
78 females.....	..	71.5
31 males.....	..	28.5

The majority of patients operated upon were between thirty to seventy years of age, with almost an equal distribution between the fourth to the seventh decades inclusive.

The duration of symptoms in this group of 109 cases is shown in Table III. In this

series, 30.2 per cent came to operation with symptoms of less than one year's duration; 8.2 per cent of cases had symptoms from one to two years; 19.2 per cent from two to five years; 23.8 per cent from five to ten years, and 18.3 per cent had symptoms from ten years or over.

TABLE II

Age Groups—Years	No. Cases	Per Cent
10 to 20.....	1	0.9
20 to 30.....	5	4.5
30 to 40.....	17	15.5
40 to 50.....	24	22.0
50 to 60.....	26	23.8
60 to 70.....	28	25.6
70 to 80.....	7	6.4
80 and over.....	1	0.9
Total.....	109	

TABLE III

Duration of Symptoms	No. Cases	Per Cent
Less than 1 year.....	33	30.2
1 to 2 years.....	9	8.2
2 to 5 years.....	21	19.2
5 to 10 years.....	26	23.8
10 years and over.....	20	18.8
Total.....	109	

TABLE IV

	No. Cases	Vomit- ing	Per Cent	Chills	Per Cent	Jaundice	Per Cent
Stones in common duct.....	53	48	90	33	62	40	75
Débris in common duct.....	12	11	91	8	66	10	83
No stones in common duct.....	44	32	72	12	27	23	42
Total.....	109	91	83	53	48	73	67

In studying the symptoms of these cases, interest was chiefly directed toward those which point to involvement of the extra-hepatic biliary ducts, namely, vomiting, jaundice, chills and fever. In compiling the statistics of jaundice, those with a clinical

history of jaundice are included as well as those cases with elevated icteric index at the time of admission to the hospital.

In the cases that had definite stones in the common duct, the incidence of vomiting was 90 per cent. Chills and fever were present in 62 per cent of the patients, jaundice in 75 per cent. In the cases in which only débris was found in the common duct, vomiting, chills and fever occurred in about the same proportions as in the cases with definite stones, but there was a higher incidence of jaundice. In the cases in which there were no pathological findings in the common duct, the incidence of vomiting was somewhat less (72 per cent). Chills and fever were present in only 27 per cent of the cases. Jaundice was present in 42 per cent.

Prior to the use of vitamin K, there was postoperative bleeding in six of the above patients with obstructive jaundice. Three died from hemorrhage, and in three cases, bleeding was controlled by repeated transfusions and by the use of intravenous calcium gluconate.

In nine of the above cases, of common duct stones, there was associated diabetes. In seven cases, the operative note read, "Pancreas was firm and enlarged." One patient was a severe diabetic for ten years, and one year prior to operation developed symptoms of pancreatitis. Following cholecystectomy and removal of stones from the

common duct, here diarrhea and foul stools cleared up and she had no further need of insulin.

The value of choledochography in surgery of the common duct cannot be over-emphasized. The work of Mirizzi,<sup>11</sup> Hicken

and Best<sup>12</sup> and others, has stressed the importance of this procedure in determining the condition of the biliary passages as

tography, by double-dose method, showed no filling of the gallbladder. At operation, a gallbladder containing many stones was removed,



FIG. 1. Cholelithogram showing filling defect in the distal end of the common bile duct and a small amount of dye in the duodenum.



FIG. 2. Cholelithogram showing normal emptying of dye into the duodenum.

to possible physiological or pathological disturbances.

Recently we have used postoperative choledochography as a routine procedure. Fifty out of 109 cases of exploration of the common duct were thus studied. We have observed cases of spasm at the sphincter of Oddi, which was relieved by nitroglycerin or atropine, and cases of narrowing of the intraduodenal portion of the common duct, due to pancreatitis or edema following dilatation of the sphincter with Bakes dilators. In one case, a diagnosis of obstruction at the second portion of the duodenum was made. In nine cases we have demonstrated stones in the common duct that were overlooked at operation.

**CASE I.** A man, aged forty-six, had an attack of middle abdominal pain radiating subternally. This occurred at 3:00 A.M. awakening him from sleep. He had had a similar attack five weeks previously. Physical examination was negative, except for tenderness under the right costal margin. Cholecys-

tomy was performed. The common duct was large and also contained several faceted stones which were removed; the common duct was drained by a T-tube. Cholelithogram done postoperatively showed obstruction of the duct due to stone at the ampulla of Vater. Some dye went past the obstruction into the duodenum. (Fig. 1.)

Fragmentation and expulsion of the stone was accomplished in this case by intraductal instillation of ether, ether and oil and the use of amyl nitrite by inhalation, according to the technique outlined by Pribram<sup>13</sup> and Hicken and Best.<sup>14</sup> (Fig. 2.)

This case, in addition to showing the value of choledochography is of interest because it illustrates the fact that expulsion and fragmentation of stones is possible by the use of ether, by increasing intraductal pressure and relaxation of sphincter of Oddi by amyl nitrite. We were successful in using this method in four similar cases.

**CASE II.** A woman, aged fifty-three, gave a history of attacks of pain in the epigastrium precipitated by fatty food, heartburn and

belching. There was no history of nausea, vomiting or jaundice. The symptoms were of several years' duration and were getting pro-

day, choledochogram demonstrated obstruction of the common duct at the ampulla of Vater, due to stone. (Fig. 3.) This stone could not be



FIG. 3. Choledochogram showing filling defect at ampulla of Vater with dilatation of bile ducts.



FIG. 4. Choledochogram showing normal emptying of dye into the duodenum.

gressively worse. Cholecystography showed poor filling of the gallbladder and a cluster of large stones was visualized. At operation, the gallbladder containing six faceted stones, measuring 1 cm. in diameter, was removed. The common duct appeared to be normal, stones could not be palpated and was not explored. The patient was well for two years. She was readmitted to the hospital two years later, severely jaundiced and semicomatose. Four days prior to her admission to the hospital, she had a sudden attack of colicky pain in the right upper quadrant of her abdomen with radiation of pain to her back. On the day of her admission to the hospital, she had three severe chills, temperature 102.8°F., icteric index 130, white blood cells, 16,000. The liver edge was felt three fingers below the costal margin. A diagnosis of septic cholangitis, with obstruction of the common duct was made. At operation, the duct was large and edematous, and on opening it, pus under pressure, escaped. A T-tube was inserted; further exploration of the common duct was not attempted because of the poor condition of the patient. Her stools continued to be acholic and on the eighth postoperative

dislodged by intraductal administration of ether, ether and oil and the use of amyl nitrite. Eighteen days later, the stone was removed transduodenally. The patient made an uneventful recovery. (Fig. 4.)

This case illustrates the necessity of exploration of the common duct even in some cases without jaundice, and that stones may be overlooked if the operator is satisfied with palpation alone.

CASE III. A man, aged sixty, was admitted to the hospital with a history of upper abdominal pain, chills, fever, vomiting and jaundice of two weeks' duration. He had a gastric resection for duodenal ulcer five years previously. At the present admission, a diagnosis of septic cholangitis with stones in the gallbladder and common duct was made. At operation the gallbladder was acutely inflamed, contained many stones and pus. The common duct was large, thickened, contained many stones and debris. The gallbladder was drained, stones were removed from the common duct and a T-tube was inserted. During the postoperative



course, stools continued to be acholic. Choledochogram showed a stone impacted at ampulla of Vater. (Fig. 5.) Intraductal administration of

who had previous cholecystectomy. Under this heading, we might also include several cases that were subjected to secondary

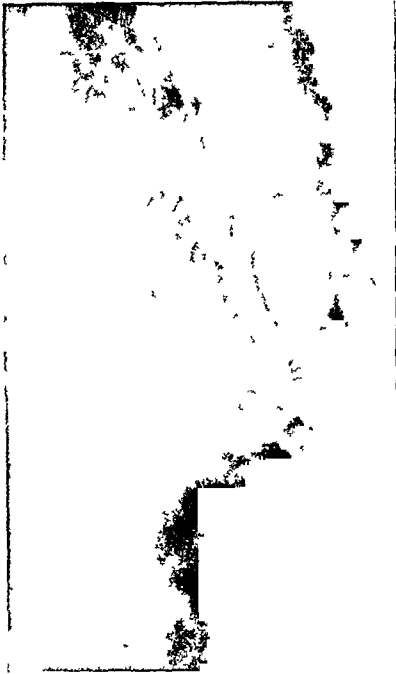


FIG. 5. Choledochogram showing filling defect at ampulla of Vater with marked dilatation of ducts.



FIG. 6. Choledochogram showing normal emptying of the dye into the duodenum.

ether, ether and oil and amyl nitrite by inhalation, failed. The stone was removed on the thirtieth postoperative day by secondary exploration of the common duct. The patient made an uneventful recovery. (Fig. 6.)

Every surgeon must face at some time or other the problem of secondary operations on the biliary tract. These procedures are usually difficult no matter whether he himself performed the original operation, or whether the primary operation was performed by someone else. In our series, secondary operations were performed on twenty-six patients. This study was primarily directed toward determining the factors that necessitated the secondary operation. It was found that these cases may be subdivided into the following groups:

1. *Errors in judgment*—in which exploration of the common duct was indicated and was not done as illustrated in Case 11.

There were eight patients who had a cholecystostomy done previously and seven

operations with the thought of finding stones in the common duct, but at exploration, no stones were found.

2. *Error of technic*—in nine cases studied by choledochography, there was evidence of left-over stones.

3. *Unavoidable operations*—in which the condition of the patients was such that it was impossible to complete the operation without undue risk to the patient, or in which it was intentionally planned as a two-stage procedure.

4. *Recurrent formation of stones*—due to persistent infection in the common duct. There were eleven such cases in this series. In three cases, choledochography following the primary operation showed no evidence of remaining stone, the ducts were not dilated, there was no spasm at the sphincter of Oddi demonstrable, and yet within a year, there was recurrence of symptoms and at operation, reformed stones were found.

CASE V. A man, aged seventy-two, was admitted to the hospital with a history of abdominal pain, chills, fever and jaundice of six months' duration. Cholecystography showed no filling of the gallbladder and six fairly large stones. A cholecystectomy and exploration of common duct was done. The common duct contained several stones and débris. They were removed and the common duct was drained by T-tube for several months. Choledochogram done postoperatively was normal. Eight months later the patient began to complain of epigastric pain, attacks of vomiting and later of chills, fever and jaundice. He was readmitted with obstructive jaundice. After a short period of preparation, the common duct was again explored and a soft stone which crumbled easily was found impacted at the ampulla of Vater. The stone was removed and the duct was thoroughly cleaned out. His jaundice persisted for a long duration, postoperatively, but eventually cleared up, and the choledochogram was normal.

CASE VI. A woman, aged sixty-eight, complained of attacks of epigastric pain, vomiting of two years' duration. There was no history of jaundice. Physical examination showed: Heart enlarged, chiefly left ventricle; E. K. G. bundle branch block; flat plate of upper abdomen showed many stones in the gallbladder area. No cholecystogram was done. Under novocain block and nitrous oxide anesthesia, the gallbladder containing many stones was removed. The common duct was large, and contained one stone and débris. This was removed, and a T-tube inserted. Choledochography later demonstrated a stone remaining in common duct. Ether and oil was injected several times and after two normal choledochograms, the T-tube was removed. The patient remained well for a year, and then returned complaining of epigastric pain radiating to the back. The liver was large and tender. Diagnosis of recurrent stone was made, and at operation, three rounded soft stones were removed from the common duct. The patient made an uneventful recovery.

With an accurate method at our disposal to study the common duct, and ability to visualize stones overlooked at operation, we also must recognize that recurrent stones in the common duct, following exploration, is not a rarity, especially when

we have choledochographic evidence that no stones were left over at the previous operation. We must conclude, therefore, that continued infection within the ducts is frequently the cause of their formation. In our series of secondary operations, we had eleven cases of recurrent stones in the duct. Three cases had normal choledochograms following the first exploration. Such positive proof is lacking in the other cases, but the possibility that stones have reformed cannot be excluded.

Lahey<sup>15</sup> states that long continued infection within the ducts, is undoubtedly more frequently the cause of formation of stones within the ducts, than is their passage from the gallbladder into the ducts.

Out of the 586 patients who were operated upon for biliary tract disease during the five-year period, there were twenty-seven hospital deaths (4.6 per cent). The common duct was explored in 109 cases, in eighty-three as a primary operation, and in twenty-six as a secondary operation. The common duct cases accounted for seventeen hospital deaths (15.6 per cent).

Table v illustrates an analysis of the seventeen fatal cases, whose average age was sixty-two years, operative procedures performed, and details relative to death. In eight out of the seventeen deaths, we had the benefit of postmortem examination.

Three patients died of postoperative hemorrhage. These deaths occurred before the use of vitamin K. In the past two years, vitamin K has been used routinely in preparation of jaundiced patients for operation, and no deaths from hemorrhage occurred.

In two cases, associated carcinoma of the lung was found on postmortem examination.

One patient had a carcinoma of the gallbladder complicated by common duct stone, and septic cholangitis.

One patient died from pulmonary embolism and three from coronary thrombosis. Three patients died from pneumonia, and one from hepatorenal insufficiency. Three patients died from peritonitis.

Some of the patients who were admitted for secondary operations, had two or three previous operative procedures on the common duct. Most of the above patients had associated cardiovascular disease, and a history of attacks of obstructive jaundice for years.

At first glance at Table v, one notices the tremendous increase in mortality in the common duct cases, and an impression may

ONE HUNDRED AND NINE OPERATIONS ON THE BILE DUCTS WITH SEVENTEEN HOSPITAL DEATHS

Age	Sex	Operation	Details	Days Post-operatively
54	F	Cholecystectomy Choledocholithotomy	Severe postoperative hemorrhage 48 hrs after	2
50	F*	Cholecystectomy Choledocholithotomy	Postoperative hemorrhage, acute necrosis of liver	1
52	M*	Cholecystectomy Choledocholithotomy	Gas bacillus peritonitis, Lannec cirrhosis of liver	4
53	M*	Cholecystectomy Choledocholithotomy	Generalized peritonitis; stones in extrahepatic ducts	4
54	F	Drainage of common duct	Thrombophlebitis; pulmonary embolism	33
66	F*	Cholecystectomy Choledocolithotomy	Metastatic carcinoma of lung	1
64	F*	Drainage of common duct	Metastatic carcinoma of lung	7
50	F	Cholecystectomy Drainage of common duct	Carcinoma of the gallbladder	19
70	F	Pus and stones Cholecystectomy Choledocolithotomy	Complete obstruction at ampulla due to stone; bronchopneumonia	55
75	M	Cholecystectomy Exploration of common duct	Arteriosclerotic heart disease; myocardial insufficiency	24
65	M*	Cholecystectomy Drainage of common duct	Arteriosclerosis aortic stenosis; coronary occlusion	1
62	F	Cholecystectomy Choledocolithotomy	Diabetes mellitus; coronary occlusion	15
69	F	Choledocolithotomy	Hepatic renal insufficiency; third operation	19
68	M	Cholecystectomy Choledocolithotomy	Pneumonia	7
66	M*	Cholecystectomy Choledocolithotomy	Peritonitis and pneumonia	7
76	M	Cholecystectomy Choledocolithotomy	Postoperative hemorrhage	1
64	M*	Cholecystectomy Choledocolithotomy	Bronchopneumonia; bronchial asthma; hypertrophy of prostate	3

\* Postmortem.

be formed that exploration of the common duct is a dangerous procedure. Out of forty-four cases in which the common duct

was explored and no stones were found there was only 1 death and that in a male, aged seventy-five, who had advanced myocardial disease. It is believed that the increased mortality in the above cases was not due to the operative procedure, but to long continued infection in the biliary tract with associated damage to the liver parenchyma. Early operations and exploration of the common duct as a primary procedure would greatly reduce the mortality in these cases.

#### SUMMARY

1. A series of 109 cases of exploration of the common duct for stones is added to the literature for the statistical value which it may afford.

2. The pathological physiology of the extrahepatic bile ducts was discussed.

3. The value of choledochographic studies was illustrated and the postoperative use of this method was adopted as a routine procedure.

4. By the use of intraductal ether and by the administration of amyl nitrite, fragmentation and expulsion of an overlooked stone was accomplished in four cases.

5. A group of cases upon whom secondary operations on the common bile duct were performed was analyzed. In eleven cases there were recurrent stones. Three of these cases had normal choledochograms after the first operation. We believe that continued infection within the duct or disturbance in metabolism may be the cause of reformation of stones in the duct.

6. Hospital deaths were analyzed. It was believed that the increased mortality was not due to the operative procedure, but to long continued infection in the biliary tract with associated damage to the liver parenchyma, age of patients and advanced cardiovascular disease.

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ALL compound fracture patients must be protected perfectly against movement, muscle spasm, and loss of position. This is accomplished more easily and more efficiently by skeletal fixation of fracture fragments in plaster-of-paris casts than in any other way.

From—"Wounds and Fractures"—by H. Winnett Orr (Charles C. Thomas).

# ACUTE CHOLECYSTITIS\*

## A REVIEW OF 140 CASES

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IN the management of acute cholecystitis, the attending physician or surgeon is confronted with the necessity of making an important early decision. His choice as to whether conservative treatment is to be followed or operation employed is not likely to be easy. Indeed, the decision has proved so difficult in past years that conscientious men have repeatedly searched their records to find help in establishing precedents or at least general principles for the proper care of this group of patients. The trend for the most part points toward earlier surgery. Many recent writers, however, have found it unwise to be categorical in their conclusions or to lay down hard and fast rules.

Anyone who undertakes to analyze a series of these cases, as we have done, is likely to be impressed with two great difficulties: The first is the difficulty of defining the term, "acute cholecystitis," and in selecting the cases to be classed within this group. The second difficulty is encountered in deducing from the records, in a manner satisfactory for statistical tabulation, the duration of the illness prior to hospital admission. By way of definition, we have included those cases diagnosed microscopically as being acute, including also a group of gallbladders which were drained because of grossly acute disease, wherein no microscopic examination was possible. The pathological criterion has been microscopical evidence of polymor-

phonuclear infiltration of the gallbladder wall.

The objection may be raised that all of these patients did not present the clinical picture and, therefore, the clinical problem of acute cholecystitis. While this is true, they did on the other hand present the pathological picture and were, therefore, liable to the complications and sequelae, whether recognized or not. The series considered in this study represents the records of 140 patients suffering from acute cholecystitis who were operated upon at the Union Memorial Hospital during the period from September, 1923, to November, 1940. There were twenty-seven different operators of whom twelve were Resident Surgeons and seventeen Visiting Surgeons (two were in both categories).

### AGE AND SEX

Acute cholecystitis is a disease of middle and late middle life. Sixty-three per cent of the patients were between the ages of thirty and sixty. If the ages are grouped by twenty-year periods (Table 1), the largest number of patients (sixty-five) falls between forty and sixty years. Age had a very definite effect on mortality. Of 106 patients sixty years of age and under, only three died, a mortality rate of 2.8 per cent; while of thirty-four patients sixty-one and over, nine died, a mortality rate of 26.5 per cent. It can be seen (Table 1) that the rate rises with each succeeding twenty-year period.

\* From the Surgical Service of the Union Memorial Hospital, Baltimore, Maryland.

Acute cholecystitis is also a disease which affects the female far more often than the male. One hundred, or 71 per cent of the patients were women, while forty, or 29 per cent were men. The men suffered a mortality of 15 per cent while the women's mortality was only 6 per cent.

TABLE I  
COMPARATIVE MORTALITY RATES ACCORDING  
TO AGE GROUPS

Age Groups	No. of Cases	No. of Deaths	Mortality, Per Cent
0-20.....	1	0	0
20-40.....	35	1	2.9
40-60.....	65	2	3.1
60-80.....	37	8	21.6
80.....	2	1	50.0
Under 60.....	106	3	2.8
Over 60.....	34	9	26.5

#### PREOPERATIVE PERIOD

Nausea or vomiting or both occurred in 85 per cent of the patients. Pain was almost a universal symptom. The palpation of a mass has been frequent though in our experience uncertain. One likes to believe in many instances that he is feeling a distended gallbladder, but the mass may well prove to have been muscle spasm, liver or gallbladder surrounded by indurated omentum and other structures.

Clinical jaundice was noted as being present in 20 per cent of the ninety-six cases in which a definite record was made. Yet in only five patients of the 140 operated upon was the common duct explored. This small number of explorations is striking and is a smaller proportion than in most series reported. One of the five died. In this hospital, the policy toward exploring the common bile duct has always been a conservative one, especially so in the face of acute cholecystitis.

The duration of symptoms prior to operation is shown in Table II. It is to be noted that nearly one-half of the patients had had symptoms for more than a week. Many of these instances of prolonged symptoms

doubtless represented "acute on chronic" cholecystitis. While the numbers of cases are small, it is interesting to record that all of the deaths which took place in the first three days occurred within the first twenty-four hours. The mortality began to appear again after the third day.

TABLE II  
COMPARATIVE MORTALITY RATES ACCORDING TO THE  
DURATION OF SYMPTOMS PRIOR TO OPERATION

Duration of Symptoms Prior to Operation	No. of Cases	No. of Deaths	Mortality, Per Cent
Less than 24 hours.....	14	3	21.4
24 to 48 hours.....	12	0	0
48 to 72 hours.....	3	0	0
4 and 5 days.....	26	1	3.8
6 and 7 days.....	15	1	6.7
8 to 31 days.....	42	4	9.5
More than 31 days.....	20	0	0
History inaccurate.....	8	3	36.5

The time elapsing from hospital admission until operation (Table III) represents a choice on the part of the attending physician or surgeon. Here he has had the opportunity to exercise discrimination which he may not have had in the period preceding hospitalization.

TABLE III  
COMPARATIVE MORTALITY RATES ACCORDING TO TIME  
ELAPSING FROM HOSPITAL ADMISSION UNTIL  
OPERATION

Time Elapsing from Admission until Operation	No. of Cases	No. of Deaths	Mortality, Per Cent
Less than 24 hours.....	39	7	18.0
24 to 48 hours.....	33	2	6.0
48 to 72 hours.....	27	0	0
4 and 5 days.....	13	0	0
6 and 7 days.....	14	0	0
8 to 31 days.....	14	3	21.4

A striking fact is the high mortality (18.0 per cent) in the group operated upon within the first twenty-four hours. This corresponds with the "immediate" group of Cave.<sup>1</sup> Out of fairness to this group, it must be conceded, however, that it includes

the sickest patients, those who might not do well under any form of treatment. Within the following twenty-four hours there was a mortality rate of 6.0 per cent while in the next five days, there were no deaths at all in fifty-five cases. This same trend in mortality over a period of time is recorded by Fallis and McClure,<sup>2</sup> Bonn and Bachhuber,<sup>3</sup> Smith,<sup>4</sup> and many others. It is a significant observation.

*Preparation of the patient* for operation is admittedly essential when a definite diagnosis has been made. Only in rare instances is a surgeon justified in operating as quickly for cholecystic disease as he would for appendicial disease. Restoration of the biochemical balance, sedation and rest are essential elements of the treatment. This period will often involve "overnight" or even twenty-four hours. However, almost every surgeon of experience can recall one or more instances of the discovery of acute cholecystitis as the responsible lesion when he has made a working diagnosis of perforated ulcer, acute appendicitis or a similar condition requiring immediate surgery. In retrospect, such a patient might have been benefitted by a longer period of preparation, but the diagnostic difficulties forestalled that opportunity.

Once the patient has been "prepared," the crux of the matter is the *pathological state* of the gallbladder. And this pathological state is likely to remain the treasured secret of the abdomen until either the illumination of the operating room or post-mortem chamber exposes it, or an undisputed cure heralds its disappearance. Surgeons are apt to emphasize to victims of appendicitis the possible discrepancies between clinical signs and pathological changes. How much greater is that discrepancy in the instance of cholecystic disease! Behrend and Gray<sup>5</sup> have correlated clinical, surgical and pathological diagnoses in 200 cases and have found wide variations. Fallis and McClure<sup>2</sup> noted a marked difference between the incidence of such complications as gangrene and empyema of the gallbladder in the surgical and path-

ological diagnoses. The surgical incidence was always higher than the pathological one. Touroff,<sup>6</sup> Heuer,<sup>7</sup> Mitchell,<sup>8</sup> and Hotz<sup>9</sup> have all noted that the symptoms of acute cholecystitis may subside and yet the lesion may progress. A partial explanation of this phenomenon may well be that the pathological changes of gangrene and perforation are largely dependent upon vascular occlusion, usually thrombosis of the cystic artery. This is hard to predict and impossible to combat.

As a result of these observations, it appears logical that the patient whose symptoms are persisting or are slowly subsiding should have the advantage of prompt operation. A progressive pathological change may thus be arrested. The patient whose symptoms have rapidly diminished is entitled to further diagnostic study if necessary, and may then be managed as a case of chronic cholecystitis. Operation will then usually be advised to avoid any recurrence of the attack and again to obviate the chance of a continuing acute process, even though that chance is remote.

#### OPERATION

From the *diagnosis at operation*, there were fourteen cases (10 per cent of total) which showed perforation. Six of these patients succumbed, a mortality rate of 42.8 per cent. Forty cases (29.2 per cent of total) showed gangrene including nine which had perforated. Of these forty cases, 7 patients died, a loss of 17.5 per cent. Of 139 patients with complete records, 103 were diagnosed grossly as having acute cholecystitis in one form or another and thirty-six as being chronic or subacute. One patient in the latter group who succumbed had been subjected to a gastric resection in addition to cholecystectomy.

The advantage of cholecystectomy over cholecystostomy is generally admitted. Many writers have expressed definite opinions on this matter including Smith,<sup>10</sup> Stone and Owings,<sup>11</sup> Heuer,<sup>7</sup> and Fowler.<sup>12</sup> Fallis and McClure<sup>2</sup> were able to state that the gallbladder was removed in all 320

patients in their series. This indeed is a remarkable record. There are times, however, when the operator is thoroughly justified in limiting the operation to drainage of the gallbladder, because anything further might be at the risk of life or serious complication. For instance, attempts at separating the gallbladder from a densely adherent duodenum might run an unnecessary risk of duodenal fistula. Excessive inflammation about the ducts may well be a contraindication to removal of the organ in an especially ill patient. In our experience, however, it is difficult to tell very much about the duct area until the operation is well advanced. If the gallbladder is being removed from above downward, which we believe to be the safest way in these cases, the ducts can usually be safely identified. If not, the gallbladder can be amputated at a level which is safe and a small fragment left behind. Although on two occasions we have thus cut across the gallbladder removing the major portion, we have in each instance by that very act obtained so much better exposure that the ducts were readily identified and the remaining fragment removed, with satisfactory ligation of the cystic artery and cystic duct. Partial cholecystectomy as advocated by Estes<sup>13</sup> or as advocated by Thorek<sup>14</sup> has not been carried out in this series.

TABLE IV  
COMPARATIVE MORTALITY RATES ACCORDING TO TYPE OF OPERATION PERFORMED

Type of Operation	No. of Cases	Per Cent of Total	No. of Deaths	Mortality, Per Cent
Cholecystostomy.	28	20	7	25.0
Cholecystectomy.	112	80	5	4.5
Total.....	140	100	12	8.6

The patients who have been subjected to cholecystostomy have for the most part been either extremely ill or have had complicating circumstances. This accounts in part at least for the higher mortality of this operation. The mortality in this series in

twenty-eight cases of cholecystostomy was 25 per cent, while that in 112 cases of cholecystectomy was 4.5 per cent. (Table iv.) Hotz<sup>9</sup> reports a 29.6 per cent mortality in fifty-seven cholecystostomies and believes that the disproportional mortality cannot be entirely ascribed to the poor risk of the patients. Furthermore, he points out a high mortality rate (20 per cent) among his series for patients who survived cholecystostomy but returned later for cholecystectomy. This may be taken as an added argument, if one is needed, for primary removal of the gallbladder. Certainly, personal experience has convinced us of the great technical difficulties inherent in the secondary removal of a previously drained gallbladder.

#### POSTOPERATIVE COURSE AND COMPLICATIONS

Although statistics are not available to prove the point, it is our distinct impression that patients today have far smoother courses following cholecystectomy than they did when less attention was paid to fluid balance and especially to the value of intravenous glucose. The administration of glucose before operation, at the operating table and during the early postoperative days has meant more in avoiding prolonged nausea and functional liver disturbances than has any other factor. Nevertheless, a large percentage of patients undergoing operation for acute cholecystitis will have complications, many of them serious. In this group 31 per cent developed some complication.

Pulmonary complications were recorded as occurring in six patients or 4.3 per cent of the series. There were three cases of pneumonia, two of them fatal, one case of atelectasis, one case of pulmonary infarction and one case of massive collapse of the lung. Myocardial disturbance occurred in four instances, or 2.9 per cent of all the patients. Three of these patients succumbed, two of "cardiac failure" and one of auricular fibrillation coupled with uremia. The fourth case developed auricular



fibrillation but survived. Peritonitis was given as the cause of death in four cases, making an occurrence of 2.9 per cent. The failure to obtain positive cultures from the contents of the gallbladder in many instances of acute infection is one explanation for the low incidence of peritonitis. Post-operative hemorrhage occurred twice and was fatal in one case. Other fatal complications occurring in one case each were shock and intestinal obstruction. In addition there were two cases of saphenous phlebitis and one case of evisceration. Prolonged drainage or wound infection took place in eleven patients or 7.8 per cent. The remaining twelve patients had complications of a minor degree or of extreme rarity.

Although the sulfonamide drugs have not been used sufficiently in this group of patients to warrant any statistical deductions, these drugs will undoubtedly prove helpful in combating many of the complications of acute cholecystitis. These complications are quite comparable to those of acute appendicitis in which morbidity has been lessened materially by their use.

#### MORTALITY

There were twelve deaths in the 140 cases subjected to operation, a mortality rate of 8.6 per cent. Seven of the deaths occurred among the group of twenty-eight undergoing drainage of the gallbladder, yielding a mortality rate of 25 per cent for this group, while five deaths occurred among the 112 patients undergoing cholecystectomy, a mortality rate of 4.5 per cent. The gallbladders of the seven patients who succumbed following cholecystostomy were all gangrenous, five of them having perforated. Of the five patients succumbing after cholecystectomy, the gallbladders of three were gangrenous and of two were acutely inflamed without gangrene. There were three autopsies. Death was apparently due to peritonitis in four instances, to cardiac failure and to pneumonia in two instances each, and to hemorrhage, auricular fibrillation, intestinal obstruction and shock in one instance each. There were no

instances in which hyperpyrexia and coma preceded death, suggesting hepatic insufficiency or "liver death." Operation within the first twenty-four hours either after onset or after hospital admission carried a higher mortality than during subsequent days.

#### DISCUSSION

In general, early removal of the acutely inflamed gallbladder gives satisfactory results. However, immediate operation following hospital admission is rarely advisable and in fact is only recommended when the differential diagnosis from a condition requiring such surgery is not possible or when a free perforation is suspected. A period of preparation is undertaken during which time the fluid balance is restored, the liver glycogen augmented and the patient given sedatives. During this period of observation it may be possible to ascertain in general "which way the wind is blowing." While it is to be emphasized that clinical signs and pathological changes do not altogether coincide, the clinical changes are at least the best indication available of the direction the trend is taking. Thus if the temperature and leucocyte count are rising, and the abdominal tenderness increasing, the indication is for prompt exploration. If, on the other hand, the reverse is true, the logical course is to let the patient improve and gain what he can from a short period of more normal physiological processes. Operation may then be carried out safely within a week from the time of his hospital entry. In this way one is enabled to use the time element to the advantage of the patient within the limits of the errors of personal judgment. One cannot be entirely categorical in this matter, but must rather exercise intelligent judgment based on his own experience and the experience of others, toward the end of prompt and sustained recovery.

#### SUMMARY

1. Difficulties in defining "acute cholecystitis" and in deducing accurate informa-

tion about the duration of symptoms prior to hospital admission are encountered in any such study.

2. Acute cholecystitis is a disease of middle and late middle life. Mortality was definitely affected by age, the rate for those who were sixty years of age and under being 2.8 per cent while for those over sixty, it was 26.5 per cent.

3. Jaundice was noted in 20 per cent of the recorded cases; yet in only five of the 140 operations was the common bile duct explored. This illustrates an extremely conservative point of view as regards choledochostomy.

4. Approximately one-half of the patients had had symptoms for more than a week. While the mortality was highest in the fourteen patients operated upon in the first twenty-four hours, it became high again only after a week. Considering mortality again on the basis of time elapsing from hospital admission to operation, the rate was still highest for the first twenty-four and even forty-eight hours but was nil for the next five days, rising again by the eighth day.

5. The pathological state of the gall-bladder becomes the crux of the matter, but its determination is difficult due to the discrepancy between clinical signs and pathological changes.

6. The operation of cholecystostomy was accompanied by a mortality rate of 25 per cent while for cholecystectomy the rate was 4.5 per cent. While this is partially explained by the greater degree of morbidity of patients undergoing the former

operation, it emphasizes the importance of complete removal whenever possible.

7. Thirty-two per cent of the patients developed some postoperative complication. These complications are listed.

8. The total mortality rate for 140 cases was 8.6 per cent. Ten of the twelve gall-bladders of patients who died were gangrenous. There were no instances of "liver death."

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# PREVENTION OF SHOCK IN SPINAL ANESTHESIA

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**M**OST authors now agree that spinal anesthesia, if properly used, is the nearest to an ideal anesthetic. The steadily increasing number of spinal anesthetics administered supports this statement. Stanley,<sup>39</sup> judging from twenty-five years, experience, states that "the use of spinal anesthesia in the majority of cases is preferable to that of inhalants."

Much has been done to make spinal anesthesia a safer procedure since the time when August Bier, in 1898, first used it.<sup>28</sup> However, there is still considerable to be done to make spinal anesthesia safer.

The advantages of spinal anesthesia are manifold. Maxson,<sup>28</sup> Schlaepfer,<sup>34</sup> Graham and Brown,<sup>17</sup> Newton,<sup>31</sup> Youngblood,<sup>45</sup> Foss and Bush<sup>33</sup> and others have discussed them in detail, hence the most important only will be considered.

This method provides optimal surgical anesthesia with complete muscular relaxation making an atraumatic operative dissection possible. The intestines are contracted and reduced in size, giving the surgeon more room for easy palpation and exposure without traumatizing by packing away of distended loops of intestines and there is no necessity for forceful retraction. By avoiding trauma postoperative adhesions as well as discomfort, distention and gas pains are decreased. The hyperperistalsis of the intestines and the relaxation of the anal sphincter cause the passage of flatus reducing the amount of gas present. During rectal operations the complete relaxation of the anal sphincter is of the utmost importance. All these conditions, favorable for the surgeon, improve his technic and shorten the operative period.

The gentleness with which a perforated duodenal ulcer or ruptured appendix can be exposed and the absence of various respiratory efforts which are associated with the

induction of inhalation anesthesia and which promote the spilling of the intestinal contents, greatly decrease the mortality from these conditions. Graham and Brown<sup>17</sup> go so far as to say: "A surgeon who operates upon a patient suffering with acute intestinal obstruction using inhalation anesthesia if adequate facilities for spinal anesthesia are available, is guilty of malpractice."

Due to the decrease in blood pressure, the amount of bleeding is less. According to Schlaepfer<sup>34</sup> there is much less evidence of postoperative shock than after the use of any other form of anesthesia. This is due not only to the decreased amount of trauma and hemorrhage but also to the blockage of shocking influences coming from the operative field because of the interruption of the afferent nerve path by the anesthetic. Postoperative nausea and vomiting is practically negligible.

The cough reflex is not abolished, which is of great importance in chest surgery as well as in preventing the development of atelectasis and pneumonia which may follow general anesthesia.

Further advantages are that no complicated apparatus is necessary, that emergency operations may be performed on a patient who can not be prepared and who, because of his full stomach, would be unfit for inhalation anesthesia. There is no respiratory, cardiac, hepatic or renal irritation and, therefore, no contraindication to the use of spinal anesthesia in the presence of tuberculosis or otherwise damaged lungs or kidneys. It is especially indicated in diabetes. Altman and Fenz<sup>1</sup> showed that after spinal anesthesia the increase in blood sugar is much less than after ether anesthesia.

However, spinal anesthesia has some disadvantages: It is a "one shot" procedure; the entire calculated dose must be given at

one time and the relatively short duration limits the operative time. This, however, is eliminated by the "continuous spinal anesthesia" method of Lemmon<sup>26</sup> to be discussed later.

There are certain limitations as to the age of the patient. Co-operation of the patient is essential and cannot be expected from children. In the aged it has the usual dangers of any other kind of anesthesia.

The limitation to operations beneath the diaphragm is controversial and there are a number of reports in the literature of spinal anesthesia having been used successfully and without great mortality in operations on the chest, neck and head.<sup>3,8,12,13,19,28,31</sup>

Burch, Harrison and Blalock<sup>4</sup> have shown that the tolerance to hemorrhage is less under spinal anesthesia than under ether. Maxson<sup>28</sup> is of the opinion that "the chief danger of spinal anesthesia is the lack of experience and judgment of the anesthetist" and supports this statement by the fact that all statistics on spinal anesthesia mortality show a higher death rate in the first one hundred injections, with a constantly decreasing level in a larger series.

The coincident fall in blood pressure which occurs in about fifty-nine out of sixty cases according to Goldfarb, Provisor and Koster<sup>16</sup> and the development of a shock-like state which is occasionally seen are of great disadvantage and danger. A thorough understanding of the causes of the development of the fall in blood pressure and shock in spinal anesthesia will, however, enable the anesthetist to prevent its occurrence and make spinal anesthesia a very safe procedure.

The causes of mortality in spinal anesthesia can be divided into two groups: Those that are due to allergy to the drug itself and those due to circulatory or respiratory failure. The former group is very rare and almost unavoidable except by skin testing. The latter group is avoidable and can be effectively dealt with by a competent anesthetist.

Most workers<sup>27,29,30,42 et al.</sup> agree that circulatory failure or shock is the result of

an uncompensated disparity between the blood and the volume capacity of the vascular system. Meyler<sup>29</sup> explains that this disparity is caused by a decrease of the blood volume due to loss of blood, dehydration or exudation of plasma, an increase in vascular capacity or a combination of both.

Normally, there are certain compensatory mechanisms that tend to restore the loss of blood volume by discharge of blood from reservoirs like the spleen and liver or absorption of fluid from other sources. Other mechanisms tend to decrease the volume capacity of the vascular bed by constricting various parts. Eppinger<sup>10</sup> has shown by x-ray that the size of the heart is decreased under such conditions; arteries are constricted, peripheral veins are collapsed and venules and capillaries may or may not be constricted. As long as these compensatory mechanisms are active and compensation sufficient, there will be no great fall in blood pressure. But when compensation fails, the blood pressure falls rapidly and progressively. Moon<sup>30</sup> says that this is not a sign of the onset of shock but of a departed opportunity and that treatment in order to be effective must be instituted before the development of circulatory failure. In other words, the treatment of shock is its prevention.

Everybody is familiar with the mechanism of the development of shock following a diminution of blood volume by excessive loss of blood or dehydration. That exudation of larger quantities of plasma into the tissues may cause shock is one of the older theories that has been evaluated and substantiated by the experiments of Eppinger, Kaunitz and Popper<sup>11</sup> published in 1935. They spoke of the state of "Seroese Inflammation" characterized by a concentration of hemoglobin, by an increased number of red blood cells and by a high hematocrit in the presence of normal plasma proteins. They concluded that plasma must have been lost from the circulation and proved this in their experiments by showing an increased production of lymph in animals in histamin shock.

Moon<sup>30</sup> worked along the same lines and popularized this theory in this country, especially by his articles published in 1940.

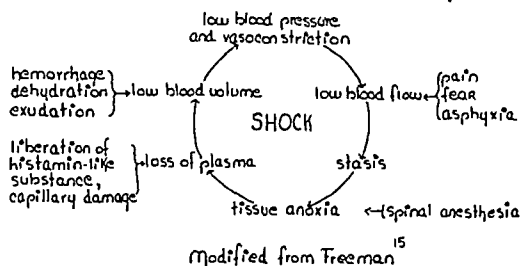


FIG. 1. The vicious circle of shock.

He points out that the capillary endothelium is a very delicate structure and that it is affected by various injurious agents like products of cellular catabolism, hormonal substances, anoxemia, etc. All these observations have been known for quite some time<sup>24, 25</sup> but he emphasized the fact that any marked reduction of blood volume flow, produced by whatever agent or mechanism it may be, will reduce the oxygenation of the tissues. This produces anoxia and subsequent capillary dilatation, with increased permeability and leakage of plasma into the tissue, causing hemoconcentration and the whole train of signs and symptoms accompanying the clinical picture of shock. He says: "Capillary atony and tissue anoxia are the main factors in the mechanism of this type of circulatory deficiency. Either of these factors induced primarily by whatever means, presently causes the development of the other. This constitutes a reciprocal relationship which gives the circulatory deficiency a self-perpetuating quality." This statement seems to be the most important concept of Moon. The realization that shock is not a static condition due to one cause but that it is a process that may be initiated by a number of things is the clue to the understanding of this complicated and much discussed problem. It seems that most investigators, although expressing so many diverging opinions about the cause of shock, were right but they did not go far enough. Probably each of the proposed causes does lead to shock but they assumed that the

factor under investigation was the sole cause, not realizing, until very recently, that it is only one factor in a larger problem. It does not matter whether shock is primarily due to a histamin-like substance liberated at the site of a large injury causing increased permeability of the capillary walls, whether it is due to fear or pain reflexly causing vasodilatation and capillary atony, an anesthetic paralyzing the vasoconstrictor nerves, or due to lack of venous return, etc. The important thing is that, if not adequately compensated, each of these factors leads to one of the conditions that is part of the vicious cycle producing a disparity between the effective blood volume and the available capacity of the vascular system. This expresses itself in the clinical picture of shock. (Fig. 1.)

The occurrence of an increase in the vascular capacity and its relation to shock needs some consideration. Normally, capillaries maintain a certain tone and only part of them are open at one time. However, under certain conditions, for example under the influence of poisons, toxins or even partial anoxia<sup>30</sup> the capillaries become atonic and do not respond to stimulation, thus withdrawing a great amount of blood from the circulation. Because of the excessive number of open capillaries and because of their atonic state, the capacity of the vascular bed is greatly increased. Dilatation of the capillaries further increases their permeability, leading to further concentration of the blood. Meyler<sup>29</sup> points out that under such circumstances blood taken from a finger prick shows a higher concentration of hemoglobin and a larger number of red blood cells than blood taken from the cubital vein. That the blood flow is much slower in such dilated capillaries and that this leads to stasis and at least to a partial tissue anoxia is easy to understand. Tissue anoxia is also produced to a certain degree by the compensatory constriction of arteries and arterioles.

Thus we see that increase in capacity of the vascular bed and decrease in the actual or effective blood volume flow aid and

promote each other in the production of shock.

A fall in blood pressure under spinal anesthesia occurs in a very large percentage of cases, one can say in almost every case. The extent of the fall varies with the individual, with the general condition of the patient and, to a certain degree, with the extent of the anesthesia. According to Maxson<sup>28</sup> it begins eight to ten minutes after injection, reaches a maximum in twenty to thirty minutes and gradually rises returning to the original level in another half hour if there is no operative shock or hemorrhage. White,<sup>43</sup> Schubert<sup>35</sup> and Henderson<sup>21</sup> among others point out that the cause of the circulatory disturbance lies not in the heart but in the periphery and consider the fall in blood pressure found in spinal anesthesia to be an expression of peripheral circulatory insufficiency, i.e., shock.

If we consider some of the events occurring in the body that are induced by spinal anesthesia injected high enough to allow work in the upper part of the abdomen, we easily can see how many factors are present which may initiate the vicious circle of shock.

Goldfarb, Provisor and Koster,<sup>16</sup> Doud and Rovenstine<sup>9</sup> et al. showed that there is a fall in systolic and diastolic blood pressure, a decrease in pulse rate, an increase in the circulation time, a decrease in venous pressure and a decrease in cardiac output. Besides this there are a vasomotor paralysis causing vasodilatation and a considerable increase in the volume of the peripheral vascular bed, a loss of resistance in the skeletal muscles which are no longer able to support the vessels adequately, leading to a pooling of the blood in the dependent parts with a reduction of blood in the effective circulation, and a fall in the respiratory volume due to the paralysis of the intercostal muscles. This leads, not only to a decreased return of oxygenated blood to the heart, but also to a decrease in venous return due to the diminution of the negative intrathoracic pressure which

has been shown to play an important part in aiding the return of blood to the heart.<sup>18,20,21,41,44</sup> et al. The depletion of tissue oxygen during high spinal anesthesia has been shown by Seevers and Waters,<sup>36</sup> Co Tui,<sup>7</sup> Lamb, Shaw and Steele,<sup>37</sup> Novak and Downing<sup>32</sup> as quoted by Burford and Leigh.<sup>5</sup> They showed that there is a great decrease in the oxygen content of the venous blood. Shaw, Steele and Lamb<sup>37</sup> in their experiments on dogs produced a typical example of stagnant anoxia by the induction of spinal anesthesia. The pooling of blood and the presence of anoxia in blood and tissues, as stated before, is considered one of the important factors in the development of shock.

Furthermore, during spinal anesthesia the compensatory mechanisms which normally come into play are made largely inactive by the paralysis of most of the white rami carrying vasoconstrictor fibers and emerging from the first thoracic to the second lumbar segments. The experiments of Burstein<sup>6</sup> on dogs also clearly indicate that there is a paralysis of the compensatory mechanism which normally regulates the blood pressure level following postural changes. Whether the paralysis of the sympathetic vasoconstrictor nerves is primarily responsible for the lack of adequate compensation or whether this is merely secondary to a depletion of adrenalin due to paralysis of the suprarenals has not yet been definitely proved. In any event the decreased power of compensation is soon followed by all the signs and symptoms of the disparity of the effective blood volume and the capacity of the vascular bed, that is by shock.

There are certain precautions to be taken before the institution is spinal anesthesia. The selection of patients is a very important point. Many of the earlier mortality statistics are high because spinal anesthesia was administered to moribund patients, to patients already in shock, and to others who could never have survived any other kind of anesthesia.

There are a few contraindications to spinal anesthesia which are accepted by most authors. They are: shock, marked toxemia, septicemia, or pyemia in which latter case a septic localization in the spinal cord is to be feared; lues, meningitis, epilepsy, apoplexy, tumors or any other lesions of the meninges or spinal cord; decompensated cardiovascularrenal disease; pleural or pericardial effusions in which ventilation already is markedly decreased; marked hypo- or hypertension; conditions that seriously interfere with the movements of the diaphragm such as extreme ascites or pregnancy with hydramnion; also any infections of the skin or other tissues around the site of injection. Elderly patients with arteriosclerosis and a history of previous vascular accidents, extremely obese patients not only because they are bad risks for any kind of anesthesia but they also may not tolerate the Trendelenburg position which may be necessary, and children and extremely nervous patients who cannot tolerate being conscious during the operation should not be given spinal anesthesia.

Proper preparation of the patient and adequate premedication is of great importance. The administration of sedatives the night before and on the morning of the operation and the reassurance of the patient with a few kind words greatly aid in the smoothness of the procedure. The routine use of ephedrine preoperatively in order to prevent the fall of blood pressure is not universally accepted. Babcock<sup>2</sup> and Hellmann<sup>20</sup> among others are against its use because it increases the work of the heart, is unreliable in emergencies, tricky and potentially dangerous. Besides, it does not act on the capillaries and as Moon<sup>30</sup> points out the arteries are not dilated in circulatory failure and ephedrine does not help the capillary atony and increased permeability caused by tissue anoxia.<sup>38</sup> However, most anesthetists use it either fifteen to twenty minutes before or right after the injection of the anesthetic, apparently to advantage. Therefore, the decision

has to be left to the judgment of the anesthetist. Maxson advises the use of ephedrine only in selected cases and not as a routine.

It is important that the patient is under proper sedation during the time of operation. Lemmon<sup>26</sup> advises that the patient should have so much morphine and scopolamine before and during the operation that he will be semiconscious and fall asleep while on the table. Other authors do not approve of the extensive use of morphine during spinal anesthesia.

The patient should be in Trendelenburg position during the operation.<sup>28,39,41,45 et al</sup> This is necessary to prevent a fatal cerebral and cardiac anemia and to enable the cardiovascular system to function properly with the aid of gravity. There are no dangers of upward extension of the anesthesia to higher and more dangerous levels when the most frequently used and safest anesthetic, namely, procain hydrochloride (novocain, neocain) is used as shown by Koster, Shapiro and Leikensohn.<sup>22</sup>

The use of oxygen during spinal anesthesia has a dual purpose. It relieves the nausea that is sometimes experienced by the patient and it increases the amount of oxygen carried in the blood and delivered to the tissues during the abnormally slow passage of the blood, and thereby breaks the vicious circle that is induced by tissue anoxia during spinal anesthesia.<sup>5</sup> Lemmon gives a continuous venoclysis of 10 per cent glucose to support the patient during the operation.

What has been said about the use of ephedrine preoperatively also holds true for the administration during the anesthesia excepting that it seems to be of no value in cases with great fall in blood pressure and shock because of its slow action, as it does not start until about fifteen minutes after injection.

Perla, Freiman, Sandberg and Greenberg,<sup>33</sup> Moon,<sup>30</sup> and Swingle, Parkins, Taylor and Hays<sup>40</sup> advise the use of adrenal cortical hormone for the prevention and treatment of shock. This hormone seems to

be concerned with the maintenance of the capillary tone. However, it has not yet been used to any large extent so that its value during spinal anesthesia has not been proved.

Last but not least the care for the comfort and psychic state of the patient is essential. The value of a well trained anesthetist who reassures the patient before and during the operation and cares for the patient's psychic and mental comfort cannot be overestimated. Occasionally, the fear and nervousness of the patient can lead to grave complications and this is one factor that usually can be prevented.

During the transportation of the patient back to his room sudden changes in position should be avoided, since the vasomotor system is not yet capable of compensating adequately for postural changes. The continuation of the Trendelenburg position accomplished by elevating the foot of the bed a few inches is very valuable in the prevention of the headaches that sometimes occur after spinal anesthesia. Intravenous infusion of normal saline has the same advantages as after general anesthesia.

Lemmon<sup>26</sup> describes a technic for continuous spinal anesthesia, in which the spinal needle is not withdrawn after the injection of novocain so that subsequent doses may be introduced as needed. In a series of about 200 cases he reports very favorable results. The continuous method enables us to eliminate several of the disadvantages of spinal anesthesia such as the administration of the entire calculated dose at one time and the limitation of the operative time. Thus Lemmon reports a maintenance of analgesia as long as four hours, requiring several doses of novocain. Furthermore, Koster, Shapiro, Warshaw and Margolick<sup>23</sup> showed in their experiments that the duration of the paralysis of the lower extremity induced with procain can be markedly shortened by the withdrawal of spinal fluid. This can easily be done during continuous spinal anesthesia so that, when any untoward reactions to the induction of the

anesthesia occur, some of the spinal fluid mixed with the drug may be withdrawn.

Altogether the use of the continuous method seems to have many advantages over the "one shot" method and seems to aid considerably in the safety of production of the anesthesia as well.

#### SUMMARY AND CONCLUSIONS

1. The great value of spinal anesthesia is indicated.
2. The disadvantages and dangers and the cause of mortality in spinal anesthesia are discussed and the conclusion reached that a thorough understanding of the processes producing a fall in blood pressure and the development of shock during spinal anesthesia is absolutely necessary for prevention of this phenomenon.
3. The modern conception of shock is outlined and the point stressed that shock is not a static condition due to a single cause, but a process that may be initiated by a number of things, any one of which may lead to the vicious circle of shock.
4. It has been shown that during spinal anesthesia ascending high enough to allow work in the upper abdomen, many factors are present that may initiate the vicious circle of shock and that this can be prevented by certain precautions taken before, during and after operation and by intelligent management during spinal anesthesia.
5. The advantages of the use of a continuous spinal anesthesia are mentioned as well as its value in increasing the safety of spinal anesthesia in general, which form of anesthesia seems to be gaining greatly in popularity due to its efficiency if properly used.

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# THE DOUBLE PIN METHOD IN THE TREATMENT OF FRACTURES OF THE TIBIA AND FIBULA\*

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THE economic trends in the past few years and the introduction of speed into our civilization have brought about rapid and drastic changes in our treatment of fractures involving the tibia and fibula.

In 1937, fractures of both bones of the leg with displacement were being treated by the introduction of a single Steinman pin through the os calcis and skeletal traction-suspension. This did not appeal to us because it required weeks of recumbency in bed and prolonged hospitalization. At this time many apparatuses for traction and distraction appeared on the market, so we decided to try the method.

Instead of placing one Steinman pin through the os calcis for direct skeletal traction we began to place an additional pin through the upper end of the tibia in order to obtain distraction of the fragments.

We believe, as do others, that too much emphasis has been placed on the open reduction of fractures for the purpose of accurately approximating bony fragments. In so doing the ultimate functional results obtained by conservative measures have been lost sight of. Many men have so keyed their senses that nothing but a perfect anatomical reduction appeals to them. While anatomical reposition of the bones is desirable, it is not a prime requisite to a good functional result. The x-ray has made us conscious of our inability to secure perfect anatomic results, and has also made our patients conscious of slight discrepancies which, as a matter of fact, are unimportant from a functional stand point.

To quote Dr. Paul Magnuson, "Plates do not reduce fractures. The fracture is reduced not by the apparatus but by the intelligent application of the fundamental principles underlying the treatment. This implies a knowledge of the anatomy, pathology, and the mechanical principles involved."

## ROUTINE PROCEDURES

1. Given a fracture of the tibia and fibula, preliminary immobilization in a Thomas splint or two lateral and one posterior bass wood splints to the upper thigh is necessary. If x-ray examination reveals a fracture of the shaft of the tibia and fibula with a tendency to displacement of the fragments, the patient is anesthetized under general anesthesia.

2. The skin is prepared with iodine and alcohol from the toes to the upper thigh. A Steinman pin is introduced through the os calcis by making a small vertical incision through the skin, one thumb's breath below the external (fibular) malleolus and on a line with the posterior margin of the fibula. The Steinman pin is then introduced through the os calcis with the aid of a Steinman pin holder. When the point is seen to protrude through the skin of the medial aspect of the os calcis, a similar vertical incision is made. If the incision penetrates too deeply, a moderate amount of bleeding occurs due to the venous anastomosis over the heel. A second pin is passed through the upper end of the tibia at the level of the tibial tubercle about one inch behind the anterior surface of the

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bone. The Steinman pin will not produce pain unless there is a drag on the skin. It is, therefore, important to check on the skin tension after the pins are inserted. Following the insertion of the Steinman pins the incisions are sealed over with cotton impregnated with collodion. No difficulty will be experienced inserting the pins at these levels if sufficient rotary pressure is used, because the bone of the os calcis offers no resistance to the introduction of the Steinman pin. However, if the pin is placed too low in the tibia, the hard cortical bone may bend the pin or break off its sharp point. These pins are stainless steel and not vitallium.

3. The limb is then placed in the apparatus (MacMillan), and pins fixed in position. Traction is applied to the distal pin through the os calcis. The proximal pin, through the upper end of the tibia merely maintains countertraction. Most cases are reduced with the aid of the fluoroscope. The fragments can be felt by manipulation; and if too much traction is made, the fracture line will gape. The reduction should be checked under the fluoroscope or by portable x-ray before the cast is applied. Rotation of the limb is checked by drawing a tape or narrow piece of bandage from the anterior superior iliac spine to the cleft between the first and second toes. This line should in most instances bisect the patella. This, however, is compared with the normal limb. Posterior bowing is the most common deformity following reduction, but this can be corrected easily by wedging the cast. If a mechanical device is not available, the reduction may be accomplished by using a fracture table. The patient is placed on the table, the symphysis pubis against the upright perineal bar. The distal pin is fastened to the foot piece and traction is made. The proximal pin is steadied with a pin clamp or attached to the overhead bar on the fracture table. A portable x-ray is taken to check on the reduction and to be certain that too much traction has not been applied.

4. Sheet wadding (splint cotton) is placed on the leg from the toes to the upper thigh. A circular plaster of Paris cast is then applied to the leg extending from the toes to the upper thigh, incorporating a thin molded plaster of Paris splint. The plaster is placed snugly around the pins incorporating them firmly in the cast.

5. The limb remains in the apparatus until the cast is hard, usually about fifteen minutes. Ordinary corks are then placed over the sharp ends of the Steinman pins and fastened in position with plaster bandage. After the patient is returned to his bed, the limb is elevated on pillows to overcome the edema.

6. Further check-up x-rays may be taken after the plaster is set. If the radiographic studies are satisfactory and the fragments are in good position, a walking iron is incorporated in the cast and the patient is made ambulatory in a few days. To give the patient added height, a shoe, not a slipper, is worn on the well foot, and some weight bearing is then allowed on the fractured limb with the walking iron. These patients are usually ready for discharge in about eight or ten days. Mental, economic and a familial hazards are overcome, and when advised as to early discharge we find that patients are more co-operative. Usually the cast and the pins are removed at the end of six weeks and the amount of motion at the site of fracture is estimated. It may be graded one, two, three or four plus in both anteroposterior and lateral directions. Very rarely union is firm at the sixth week, more frequently it is two plus in both directions. A new cast is now applied extending from the toe to the mid thigh at this time. Very little wadding is used, usually a stockinette, with a turn of splint cotton around the ankle, knee and upper thigh. At the end of three weeks, the patient is re-examined. If no motion is present, a circular cast is applied from the knee to the ankle and weight bearing increased. If the amount of motion remains stationary for a period of five to six weeks, the case is considered to be one of delayed

union. A drilling operation is then performed to stimulate callus formation. There is no hard and fast rule as to the length of time it takes a fractured tibia to unite. Except in children, the time varies from eight to twelve weeks. Compound fractures, however, may take as long as sixteen weeks. One case in our series resulted in nonunion because of the loss of a large fragment of bone at the time of injury. This case eventually came to surgery, bony union taking place following a sliding bone inlay operation.

In compound fractures in which double Steinman pins are indicated, they are introduced before the débridement is done. The fracture, however, is not reduced until after the wound has been thoroughly irrigated. Plenty of warm saline, in an irrigating can and not a bulb syringe, is used to flood and wash out the wound properly. Questionable devitalized tissue is removed. The skin edges are always resected, i.e., a thin edge of skin is removed with a scalpel. Those compound fractures operated upon within six hours of injury are closed primarily. The skin only is sutured with interrupted black silk. No drains are used. In our series no sulfanilamide nor prophylactic gas gangrene antitoxin was used. Tetanus antitoxin, 1,500 to 3,000 units, is given intramuscularly. While we give tetanus antitoxin routinely, we no longer advocate prophylactic gas antitoxin.

Since we have been treating our compound fractures by the double pin method, débridement and plaster encasement, we have not observed any gas bacillus infection. We are convinced that complete rest of the wound in plaster of Paris prevents further irritation to already injured tissues. In December, 1940, we reported results obtained in a series of eighty-five consecutive cases of compound fractures. Forty-three of these were treated by primary immediate closure of the wound. Two of these patients developed infections. One patient not infected died. Sulfanilamide, by mouth was used in only one case.

Since September, 1937, we have treated eighty-nine patients by the double pin method at the Flower-Fifth Avenue Hospitals and the Metropolitan Hospital, New York City. We believe that the results have been uniformly good. There has been no case of pin infection. The ambulatory treatment has not interfered with the fracture healing and yet has markedly reduced the cost of hospitalization.

At this time of national hysteria, when methods for the management of civilian casualties are to be considered, this method for handling slipping fractures of the tibia and fibula offers a timely solution. It is simple and rapid in execution. The patients are made ambulatory early and the hospitalization time is short.

#### SUMMARY

In fractures of the tibia and fibula with displacement, and those that have a tendency toward displacement, the double pin method is indicated. The advantages of this method are: (1) uniformity of procedure; (2) no operative team is necessary. Elaborate technic for reduction of fracture is done away with. (3) In our series, there has been no case of infection at the site of the Steinman pins. (4) Inasmuch as this method produces firm fixation, it has a particular advantage in the treatment of compound fractures. (5) The time and cost of hospitalization have been drastically reduced as compared with previous methods employed. (6) With the use of the double pin method we obtain firm immobilization of the fractured fragments as compared to the previous method of skeletal traction—suspension with one pin through the os calcis.

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# MEDIASTINAL EMPHYSEMA AND PNEUMOTHORAX FOLLOWING TRACHEOTOMY FOR CROUP\*

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## INTRODUCTION

**M**EDIASTINAL emphysema and pneumothorax have been considered rare complications following tracheotomy in croup cases. In a series at the Queens General Hospital, both complications have been seen frequently. Many of the patients with complications present few or no symptoms and probably would have remained unrecognized without routine postoperative x-rays. Some, however, are followed by the well known respiratory and cardiovascular repercussions of pneumothorax, with an occasional fatal outcome.

The route of entry of air into the mediastinum and pleural cavities has been the subject of much debate. An evaluation of all possible mechanisms and the demonstration of the most frequent pathway in this group of cases will be attempted.

## LITERATURE

Michels<sup>5</sup> has reviewed the literature recently, so that only a few references will be cited. Champney<sup>1</sup> performed tracheotomies on stillborn infants and then subjected them to artificial respiration with the tracheotomy opening partially obstructed. He noted that mediastinal emphysema occurred in all cases, and pneumothorax was listed as a frequent finding. Kies<sup>2</sup> cited one case of massive mediastinal emphysema with bilateral pneumothorax, following thyroidectomy. He injected air into the mediastinum through the sternum or jugular notch in two cadavers, and noted the development of mediastinal emphysema

followed by pneumothorax. Macklin<sup>3</sup> produced mediastinal emphysema in cats by overinflation of their lungs under high pressures. He concluded that the air ruptured through the alveolar wall and dissected back to the mediastinum by way of the perivascular lymphatics. Further injection of air led to rupture through the mediastinal pleura, with the production of pneumothorax, often bilateral. The visceral pleura consistently remained intact. He found it impossible to produce mediastinal emphysema by the injection of air directly into the pleural cavity, even though extremely high pressures were used. Simpson<sup>4</sup> reported a case of pneumothorax following tracheotomy and referred to the rarity of such a complication. Michels<sup>5</sup> added six case reports. He discussed possible mechanisms for the production of pneumothorax and suggested bronchoscopy prior to tracheotomy as a means of prevention. Barrie<sup>6</sup> described four fatal cases of pneumothorax following operations on the neck. Three followed thyroidectomy, and the fourth, tracheotomy for glottic edema. All were associated with mediastinal emphysema. He postulated the route of entry of the air to be through the operative wound into the mediastinum, thence into the pleural cavities. He demonstrated an intact cervical pleural dome in each instance by methylene blue installation into the pleural sac.

## ANATOMY

The accompanying diagrams indicate schematically all possible routes for the

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entrance of the air into the mediastinum and pleural cavities involved in cases of obstructive breathing. (Figs. 1 and 2.)

showed only limited mediastinal emphysema and no pneumothorax. (Fig. 3.)

#### CASE II. Mediastinal emphysema and pneu-

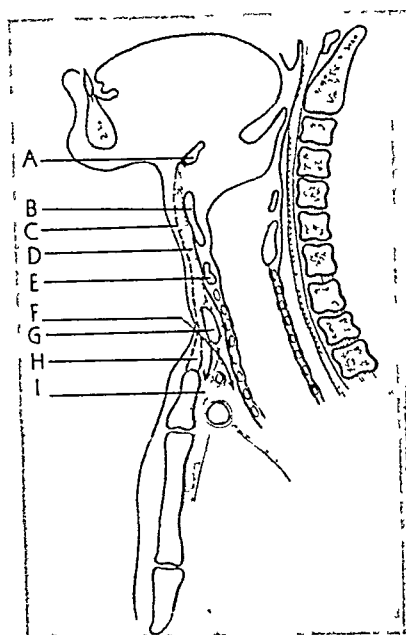


FIG. 1.

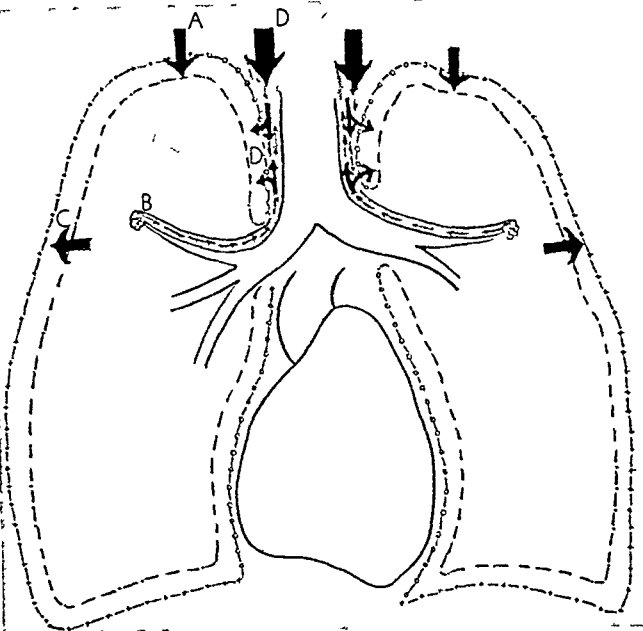


FIG. 2.

FIG. 1. Cervical fascia, demonstrating pathway of extension of air from neck into mediastinum. (Modified after Davis, Applied Anatomy, Figure 180.) A, Hyoid bone; B, thyroid cartilage; C, superficial leaflet of deep cervical fascia; D, deep leaflet of deep cervical fascia; E, cricoid cartilage; F, tracheotomy site; G, thyroid gland; H, space of Burns; I, anterior mediastinum.

----- Superficial leaflet of deep cervical fascia.

Pretracheal (deep) leaflet of cervical fascia.

FIG. 2. Possible pathways of extension of air into pleural cavities and mediastinum. A, injury to apical pleura; B, rupture of alveolus with extension to mediastinum and rupture of mediastinal pleura; C, rupture of visceral pleura; D, extension of air through tracheotomy wound between superficial and deep leaflets of deep cervical fascia into mediastinum with rupture of mediastinal pleura (usual mechanism).

- + - + Parietal pleura.

- · - · - Visceral pleura.

- 0 - 0 - Mediastinal pleura.

The variations in the route of entry of air, and in the symptomatology are illustrated by the following case histories:

**CASE I. Mediastinal emphysema causing no symptoms:** D. G., a two-year old white female, was admitted on March 4, 1940, with a twelve-hour history of respiratory difficulty following an upper respiratory infection of seven days' duration. Examination revealed a restless, pale child, breathing with inspiratory stridor. Moderately deep supraclavicular and sternal retractions were present. On laryngoscopy, a marked supraglottic edema was evident. Immediate tracheotomy was performed with instantaneous and permanent relief. Check-up x-ray on March 6, 1940

showed only limited mediastinal emphysema and no pneumothorax. (Fig. 3.)

**mothorax causing no symptoms:** J. W., a fifteen-month old white male, was admitted on January 3, 1940, with mildly obstructive respiration. A diagnosis of croup was made and conservative therapy instituted. By the next day, the respiratory difficulty had increased. Laryngoscopic examination revealed subglottic edema, and intubation was done with marked relief. On January 10, 1940, extubation led to immediate recurrence of symptoms. Because the patient repeatedly coughed up the tube, a tracheotomy was done on January 12, 1940. The patient remained comfortable after that procedure. Chest x-ray taken on January 13, 1940 revealed mediastinal emphysema, 70 per cent pneumothorax on the right, and minimal pneumothorax on the

left. A repeat x-ray on January 29, 1940 showed complete absorption of air from the mediastinum and no evidence of pneumothorax.



FIG. 3. Case I. X-ray taken two days after tracheotomy showing air limited to mediastinum (a). Lateral view shows similar sub-sternal localization of air.

**CASE III.** *Pneumothorax following injury to cervical pleura, causing respiratory distress, but not requiring intervention:* P. D., a fourteen-month old white female, was admitted on March 18, 1940 with a twenty-four hour history of progressive respiratory difficulty and a croupy cough. Trial intubation gave no relief. The child's condition grew worse rapidly, with increasing cyanosis and dyspnea. A long metal suction tube was passed through the larynx to provide an airway and an emergency tracheotomy was done. During the procedure, the pleura was seen to bulge high into the wound and the right pleural dome was injured, producing an audible hiss. The operative procedure was completed without further examination or repair of the pleura. Physical examination immediately postoperatively showed signs of a partial pneumothorax on the right. The child was perfectly comfortable at this time. By the next day the respirations had risen from thirty to eighty per minute. X-ray at this juncture revealed 80 per cent pneumothorax on the right. *No mediastinal emphysema was present.* The child improved rapidly and made an uneventful recovery.

**CASE IV.** *Mediastinal emphysema and pneumothorax requiring intervention:* C. J., a three-month old white female, was admitted on December 12, 1940, with right otorrhea and a

retropharyngeal swelling. Despite chemotherapy, the swelling progressed to such an extent by the next day, that the child showed obvious



FIG. 4. Case IV. X-ray taken immediately pre-operatively showing absence of air in mediastinum or pleural cavities.

respiratory distress. The swelling was incised but no pus was encountered. Following this, the obstruction to breathing progressed so rapidly that an emergency tracheotomy was necessary five hours later. (Fig. 4.) After exposure of the fascial planes of the neck, a technical difficulty caused considerable delay before incision into the trachea. During this interval, air could be heard *being aspirated through the wound edges* by the forceful inspirations of the infant. Immediate relief was apparent on completion of the tracheotomy. Two hours postoperatively, it was noted that the child was becoming increasingly more dyspneic. The respirations were definitely not of the obstructive type. Physical examination suggested bilateral pneumothorax. A peculiar crepitant sound was heard over the sternum, synchronous with each heart beat. An emergency x-ray (Fig. 5) revealed bilateral pneumothorax, almost complete on the left, and moderate mediastinal emphysema. Immediate partial relief was seen after the removal of 50 cc. of air under positive pressure from the left chest. Four hours later, it was necessary to again tap the left chest, with removal of about 60 cc. of air. On this occasion, the air was under negative pressure, and aspiration by syringe was necessary. Improvement thereafter was rapid. X-ray two weeks later revealed

only a slight degree of mediastinal emphysema and no pneumothorax.

CASE V. *Mediastinal emphysema and pneu-*

positive pressure was not found in the left pleural cavity, a partial collapse of the left lung is correlated with the x-ray findings of left



FIG. 5. Case iv. X-ray taken two hours after tracheotomy showing bilateral pneumothorax (b) and mediastinal emphysema (a), the latter confirmed by lateral view.



FIG. 6. X-ray taken several hours after tracheotomy, showing massive mediastinal emphysema with considerable quantity of air following contour of mediastinum (a).

*mothorax with fatal termination:* A. K., a four-year old white female, was admitted at 1 A.M. on March 5, 1940 with a twenty-four hour history of a croupy cough and dyspnea. The patient was severely ill, presenting marked cyanosis and deep supraclavicular and sternal retractions. Direct laryngoscopy revealed marked edema and redness of the larynx. Intubation was performed with only slight relief, so that tracheotomy was resorted to at noon. Immediate temporary improvement followed, but cyanosis and dyspnea soon recurred and rapidly grew worse. At 2 P.M. the patient was bronchoscoped through the tracheotomy wound. No relief from this procedure was evident. Chest x-rays taken at 3:30 P.M. revealed 60 per cent collapse of the right side and 70 per cent of the left, with "pancaking of the lung." Slight improvement was noted after aspiration of 250 cc. of air under positive pressure from the right pleural cavity, and 75 cc. from the left. One hour later, 200 cc. was aspirated from the right side and continuous decompression was started by connecting the needle with a rubber tubing placed under water. No air, however, escaped from the tubing. The child died during this procedure.

Postmortem examination revealed an extensive mediastinal emphysema and a right tension pneumothorax. Although air under

pneumothorax. The usual method of demonstrating pneumothorax at autopsy by opening into the pleural cavity under water and watching for the escape of air, will demonstrate only positive tension pneumothoraces. A negative tension pneumothorax may exist as in Case iv, because of the shift of a labile mediastinum.

CASE VI. *Mediastinal emphysema in a case of trauma demonstrating the pathway of air by way of the cervical fascia:* C. H., a twenty-year old white male, was injured while riding on a motorcycle. He was brought to the hospital in a comatose state. Respirations were rapid and labored. Multiple fractures of the bones of the face were observed. There was a large perforation through the buccal mucosa in the floor of the mouth near the frenulum. No other lacerations in the skin of the neck were present. Death occurred two hours after admission.

Autopsy disclosed marked mediastinal emphysema. Pneumothorax was not demonstrated. No rib fractures were present. Definite air bubbles were found beneath the superficial leaflet of the deep cervical fascia. The air had evidently been aspirated through the lacerated buccal mucosa. From this source, the air could dissect beneath the superficial leaflet of the deep cervical fascia only if a fracture of the hyoid bone were present. On this basis, the neck organs were investigated, and multiple



fractures through the body and greater cornua of the hyoid bone were found. It is our impression that this confirms the essential mechanism by which mediastinal emphysema and pneumothorax are produced following tracheotomy for croup.

#### COMMENT

Pneumothorax can be produced by any of the mechanisms indicated in Figure 1. In Case III, the air obviously entered the pleural cavity through a traumatic perforation of the apical pleura incurred at the time of operation. (Route A.) In the described instance, it must be remembered that the pneumothorax was unilateral and that there was no mediastinal emphysema.

Mediastinal emphysema was demonstrated by routine postoperative x-rays on twelve occasions in a series of eighteen tracheotomies on patients with croup. The observations extended over a period from November, 1939, to January, 1941. There were eight cases of pneumothorax, three of which were bilateral. *In all cases in which there was pneumothorax, there was a co-existent mediastinal emphysema.* The only exception is represented by Case III, in which the apical pleura was injured.

If trauma to the apical pleura were the usual mechanism for the production of pneumothorax, the coincidental mediastinal emphysema found in such cases would remain unexplained. To explain the high incidence of bilateral pneumothorax, one would have to postulate further that both pleural domes were injured. It is more reasonable to assume that the association of mediastinal emphysema and pneumothorax is more than coincidental. The frequent occurrence of mediastinal emphysema without pneumothorax, and the rarity of pneumothorax without mediastinal emphysema, strongly suggests that the presence of air in the mediastinum is essential for the production of pneumothorax. Weight to this supposition is added by Macklin's work showing that it was impossible for air under positive pressure to penetrate the mediastinum from the pleural

cavity, but that the opposite route was quite feasible experimentally.

How then does the air reach the mediastinum? If it were by rupture of an alveolus (Route B), with escape of air along the peribronchial and perivascular lymphatics incident to the high negative pressures developed during obstructive breathing, mediastinal emphysema should be more common *before* tracheotomy. If rupture of the alveolus occurred during the sudden inrush of air following relief of the obstruction, mediastinal emphysema should be as common *following intubation* as it is following tracheotomy. X-rays before tracheotomy failed to reveal mediastinal emphysema or pneumothorax. This negative finding would seem to make the rupture of an alveolus a less likely mechanism.

If rupture of the visceral pleura (Route C) were the cause of pneumothorax, the co-existence of mediastinal emphysema would still remain unexplained. The analysis outlined above, eliminating alveolar rupture, applies as well to rupture of the visceral pleura as the usual mechanism.

With these clinical data in mind, the following experiments were undertaken to demonstrate the probable route of entry of air into the mediastinum and pleural cavities.

#### EXPERIMENTAL DATA

Nine cadavers ranging in age from a still-birth of six months' gestation to a one-year old infant were employed. All procedures were performed with the cadaver under water, so that any leakage of air was instantly demonstrated.

*Experiment A.* A longitudinal incision was made through the skin from the symphysis mentis to the upper abdomen and the skin reflected laterally. The subcutaneous fat and muscles were removed with the skin flap over the thorax. The costal cartilages were divided close to the sternum and the ribs retracted so as to visualize the mediastinal structures. The fascial planes of the neck were then identified by sharp dissection. A No. 20 needle

was inserted beneath the superficial leaflet of the deep cervical fascia. Air was injected under positive pressure. The pressure was measured by a mercury manometer connected with the needle through a side-arm.

**Results.** Injection of air under pressures of 15 to 20 mm. of mercury beneath the superficial leaflet of the deep cervical fascia resulted in a dissection of the air down along the fascial planes into the anterior mediastinum. Large emphysematous blebs formed in the mediastinal tissues under direct observation. After injection of 20 to 50 cc. of air, no more air could enter the mediastinum unless the pressure was raised considerably. At a pressure of approximately 40 mm. of mercury there was a rapid fall to zero. Observation of the mediastinum invariably revealed a simultaneous rupture of an emphysematous bleb into the pleural cavity. The usual site was at the left inferolateral border of the thymus gland. More air could now be injected readily at much lower pressures, ranging from 0 to 5 mm. of mercury. It is significant that a slight change in the position of the cadaver was sufficient to close off this original rupture site. Whenever this occurred, the positive pressure rose to 40 mm. of mercury again, before another site of rupture could be seen. The new site was frequently on the opposite side of the mediastinum. In no case could air be identified beneath the endothoracic fascia.

**Experiment B.** Both lungs were removed with a block of mediastinal tissue. Air was injected into both main bronchi under pressure.

**Results.** Injection of air into the main bronchus resulted in inflation of the lung until no more air could be accommodated without a rise in pressure. In some cases, small bubbles of air could be seen in the subpleural lymphatics, demonstrating a possible mechanism for extension to the mediastinum. The pressure then rose rapidly to levels of 65 to 70 mm. of mercury, at which point rupture occurred, usually through the mediastinal pleura at the hilum.

Occasionally, a point of rupture was identified in the visceral pleura. Usually, local pathological conditions such as pneumonitis could then be demonstrated.

#### COMMENT

It is true that the experimental conditions of forcing air into the mediastinum under positive pressures are not duplicated exactly in a case of croup. However, an equivalent situation does exist. During the powerful inspiratory movements of croup, high negative intrathoracic pressures are developed, and serve to draw air into the lungs through the partially obstructed natural airway. With incision of the cervical fascia incident to tracheotomy, an initial pathway is established for aspiration of air through the wound edges into the mediastinum. On forced expiration, positive pressures are developed within the chest. The superior aperture to the mediastinum, which is widest during inspiration, is now at its narrowest diameter and tends to trap the mediastinal air. The positive pressure then forces the trapped air further down along the tissue planes. When appropriate pressure levels are reached for each individual case, rupture through the mediastinal pleura into the relatively unsupported pleural space occurs, with the production of pneumothorax. (Route D.) Rupture may occur on one side only. Now if this first route is temporarily obstructed by change in position of the patient, corresponding to the experimental observations, a new point of rupture may appear on the same or opposite side. *Once this fistulous tract is established*, which must happen while the patient is struggling for air, the usual intrathoracic pressures during ordinary unobstructed breathing will suffice to aspirate additional air into the pleural cavity. This accounts for the progression of the pneumothorax after the tracheotomy is completed. Thus, the usual latent period of one or more hours before the appearance of cyanosis and marked dyspnea is not surprising.

The measures for the prevention of mediastinal emphysema and pneumothorax are apparent, if the mechanism discussed above holds true. If the obstruction to breathing can be relieved by passage of a Mosher tube, or preferably a bronchoscope, as first suggested by Michels, the patient's respirations immediately become less labored. The high negative pressures essential for the production of mediastinal emphysema can no longer occur. However, if such prophylactic procedures are not feasible, it is advisable to reduce to a minimum, the interval between the division of the cervical fascia and the insertion of the tracheotomy tube.

The treatment of the complications of tracheotomy in patients with croup limits itself to the treatment of pneumothorax. In our experience, mediastinal emphysema of itself, has never caused symptoms severe enough to warrant intervention. Absorption of air in these instances occurs spontaneously over a period of days or weeks. In those cases of pneumothorax in which respiratory distress is a prominent feature, simple aspiration of air is usually sufficient to give relief. When the pneumothorax quickly reforms, continuous decompression by connecting the needle to a tube placed under water may be attempted. It must be remembered, however, that only air from positive tension pneumothoraces will be removed by this means. If the pneumothorax is under negative pressure,

as in Case IV, the air must then be actively withdrawn.

#### SUMMARY

1. Routine postoperative x-rays following tracheotomy showed mediastinal emphysema in twelve of eighteen cases. In eight, pneumothorax was also present.

2. The route of entry of air into the mediastinum and pleural cavities is discussed and the most frequent mechanism is indicated.

3. The means of prevention of the complications of mediastinal emphysema and pneumothorax are presented.

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# USE AND ABUSE OF IODINE IN THE MANAGEMENT OF GOITER\*

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ABOUT the year 1200, Roger von Salerno discovered that the administration of ground sponges and seaweed benefited some of his patients afflicted with goiter. This type of treatment for goiter persisted through the ages, but it was not until 1812 that Condiet<sup>1</sup> ascertained that iodine is the active principle of the sponges and seaweed. In 1863, Trousseau,<sup>2</sup> by mistake, gave a patient suffering from a severe exophthalmic goiter fifteen to twenty drops of iodine daily in place of digitalis. After a fortnight's treatment with iodine, there was a marked clinical remission. The pulse rate was reduced from 150 to less than 90 beats per minute; the patient was less nervous, and had a sense of well being. When the mistake was discovered and the iodine was replaced with digitalis, the symptoms immediately reappeared and the patient could not be adequately controlled again. Condiet<sup>3</sup> had advised against the indiscriminate use of iodine in all cases of goiter.

In 1896, Baumann,<sup>4</sup> experimenting with animals, demonstrated that iodine is normally present in the thyroid gland; later, he and Oswald<sup>5</sup> showed that iodine is contained in the colloid of the follicles. When there was a deficiency of iodine in the animal's diet or water, a hyperplastic goiter developed. When iodine in sufficient amounts was administered to an animal with a hyperplastic goiter, the follicles became distended with colloid and a colloid goiter resulted. Baumann<sup>4</sup> and Oswald<sup>5</sup> had the impression that a colloid goiter is in a resting state and represents a hyperplastic gland's nearest approach to normal,

not only as to histological appearance but also chemical composition. They showed that a hyperplastic goiter contains the least iodine, a colloid goiter more, and a normal gland the most. Oswald<sup>6</sup> demonstrated that the active principle of the thyroid is contained in a globulin, which he called thyroglobulin, and that the thyroid of animals in endemic goiter areas contains less iodine than the thyroid of those in non-endemic areas.

In 1907, Marine<sup>7</sup> published the results of his studies on the physiology, anatomy and pathology of the thyroid gland. Later, Marine<sup>8</sup> and Williams continued the work of Baumann and Oswald. At this time, Kocher<sup>9</sup> repeatedly warned against the general use of iodine for all patients with goiter. To quote Boothby,<sup>10</sup> "We are indebted to Kocher for first extensively collecting and presenting the evidence that the indiscriminate use of iodine to patients having goiter is attended with danger." Kocher found it inadvisable to give iodine to patients having a hard, nodular, "meaty" type of endemic goiter, which we know today as nontoxic adenomatous goiter. He found that iodine produced toxicity in this type of goiter.

Kendall,<sup>11</sup> in 1914, isolated the crystalline iodine containing the active principle of the thyroid, which he called thyroxin. This substance has been shown repeatedly to have all the active physiological properties of dessicated thyroid extract. Thyroxin contains about 65 per cent iodine. The body uses about  $\frac{1}{3}$  mg. of thyroxin daily, and it is estimated that there are about 12 to 14 mg. grams of thyroxin in the body at one time.

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## THYROID AND PREGNANCY

The functional state of the thyroid should be determined before any medication is administered. There is an extra demand placed on the thyroid during pregnancy; however, this condition is frequently evidenced by the varying degrees of hyperplasia and hypertrophy which develop. Comparable to this is the hyperplasia which develops in the adolescent individual living in an endemic area when there is a deficiency of iodine. If the pregnant individual lives in an endemic area and her basal metabolic rate is normal, it is well to administer 10 to 20 drops of Lugol's solution weekly. This should prevent goiter in the mother and cretinism or hypothyroidism in the offspring. Breitner<sup>12</sup> states that after five generations of colloid goiter, we may expect to find deaf mutism and idiocy. This should suggest that the expectant mother who has a colloid goiter or evidence of a hypothyroid condition should receive appropriate treatment in order to prevent the child from being hypothyroid at birth. An associate's case clearly shows this. He had under his care three children who exhibited many of the clinical signs of hypothyroidism; such as, mental and physical retardation, broad, spade-like hands, short little fingers, fat bellies with umbilical hernias, dry skin, coarse thin hair, large thick tongues, drooling saliva and delayed ossification of the wrist bones. The mother of these children had a large colloid goiter with a basal metabolic rate of minus thirty-two. During the next pregnancy, she was given thyroid therapy. The baby was born normal in every respect. Later, she moved to another region. She became pregnant again, received no thyroid treatment, and delivered a very definite cretenoid.

NONTOXIC DIFFUSE OR SIMPLE  
COLLOID GOITER

This type of goiter is prevalent in the endemic areas of the world, but sporadic cases are frequently noted. It develops

before or during the adolescent period but may appear in the late teens or during pregnancy. As a rule, it disappears before the twenty-fifth year. In the absence of an adequate supply of iodine, the physiology of the thyroid is disturbed, and a deficient amount of thyroxin is delivered to the tissues, causing hypothyroidism. This altered physiology stimulates the thyroid, and hyperplasia and hypertrophy result. A decreased amount of colloid is seen in the early stage of this form of goiter. The thyroid is diffusely enlarged, smooth, and elastic, and no nodulations are felt. The vascularity is not increased, as there is an absence of thrills, pulsations or bruits. In 1917, Marine<sup>13</sup> and Kimball, working with the school children in Akron, Ohio, demonstrated that this type of goiter could be practically controlled by administering 2 Gm. of sodium iodide twice a year. The iodine was given over a period of two weeks each spring and fall. Later, they suggested that 10 mg. of sodium iodide be administered each week throughout the year, as this would give a more even distribution of the iodine and prevent an overdose. Klinger<sup>14</sup> of Zurich, Switzerland, adopted a similar method of control in that great endemic area. He incorporated the 10 mg. of iodine in a chocolate tablet and called it "Idostarine." The tablet is stable and more pleasant for children to take. McClure<sup>15</sup> of Detroit detailed before this association the results of the use of iodized table salt in Detroit from 1924 to 1937. Iodized table salt contains .01 per cent of sodium iodide. The average consumption of salt per individual is about eight pounds annually, which gives him about 1 mg. of sodium iodide daily. In 1924, the incidence of simple goiter among the school children of Detroit was 35 per cent. In 1936, or twelve years later, the incidence of simple colloid goiter was 2.6 per cent.

When a colloid goiter is present in the late teens or in early adulthood, the administration of too much iodine must be carefully avoided. This fact was stressed in 1907 by Kocher<sup>7</sup> and again in 1925 by

Plummer,<sup>16</sup> both of whom noted that large doses of iodine induced activation. Most of the colloid goiters we have seen showed definite evidence of hypothyroidism, namely, dry skins, listlessness, and basal metabolic rates below the average normal, usually minus fifteen or twenty. In the large goiters, thrills, bruits and pulsations are often noted over the superior thyroid arteries. Dessicated thyroid extract has proved of value in treating these patients; younger individuals require  $\frac{1}{2}$  or 1 gr. daily, and older individuals, with large colloid goiters, 1 to 2 gr. The pulsations and bruits disappear as the gland shrinks. These cases must be constantly observed for any signs of activation. After two or three months, the gland has shrunk enough to permit the detection of any adenomas. If adenomas are not present, the patient should be given Lugol's solution, 10 drops twice a week, along with the thyroid extract. This treatment is a prolonged one, and it may be stated that the older the individual the more unsatisfactory the treatment. When iodine is indiscriminately used over long periods of time in colloid goiter, symptoms of hyperactivity may appear, and the inactive gland is converted into the active hyperplastic type, as Goetsch<sup>17</sup> has shown.

#### NONTOXIC ADENOMA

Any nodular enlargement of the thyroid is presumed to be adenomatous. There are two general types of adenomas: The fetal type is a true tumor of the thyroid gland, having its origin, according to most investigators, in the interacinar cell remnants of Wolffler. In the earliest stages of the fetal adenoma, the tissues simulate those of a four or five month fetus. The acini are poorly developed and there is an absence of colloid material. The adenoma, being encapsulated, is free from periodic cycles of hyperplasia and involution, which are common to the normal gland.

Colloid adenomas are by far the most frequent type; these are found throughout

the world, although more frequently in endemic areas. The readily discernible enlargement is produced by multiple growths throughout both lobes and the isthmus. Plummer<sup>16</sup> states that this type of goiter always has its inception in the colloid goiter. Reinhoff<sup>18</sup> is of the opinion that they are "involutional bodies," areas of tissue which have regressed or failed to regress during hyperplasia and involution. Still others contend that they are produced by the indiscriminate use of iodine in colloid goiters. There is very definite clinical evidence to the effect that iodine, especially in large doses, activates this form of goiter. Plummer and Jackson<sup>19</sup> advised against its use, especially in older patients. Very toxic adenomatous goiters are found in individuals under thirty years of age who had no symptoms of toxicity until they began taking iodine in varying amounts over a period of a few weeks to several months. McClure<sup>20</sup> states that after the introduction of iodized salt in Detroit (in 1924), there was (in 1927) a gradually increasing number of goiter patients coming to operation, in spite of, or perhaps because of, the introduction of iodized salt. The majority of the cases were of the nodular toxic type. Also in 1927, the death rate from goiter in Detroit reached its peak. In 1926, Hartsook<sup>21</sup> had reported that many individuals with nontoxic goiters were precipitated into activity by iodine. Later, McClure reported that the number of goiter operations had gradually declined in Detroit, since the incidence of colloid goiter decreased from 35 per cent in 1926 to 2.6 per cent in 1927. As stated above, Plummer<sup>27</sup> demonstrated that adenomas have their inception in colloid goiters. This type of goiter, once present, does not disappear; it tends to become toxic in later years, and malignant degeneration takes place in 6 to 8 per cent of the cases. It is, therefore, strictly a surgical condition and can be removed safely with practically no risk. If not removed, its course is constant and progressive, and, as Hertzler<sup>22</sup> affirms, "This type of goiter kills the patient unless

some intercurrent disease anticipates this end." Iodine should not be used for treatment and is not necessary in preoperative preparation.

#### TOXIC NODULAR OR ADENOMATOUS GOITER

The evidence of toxicity in this type of goiter develops gradually. The patient is not incapacitated for many years after the appearance of the goiter, unless the toxicity is induced by the indiscriminate use of iodine. The cardiovascular system receives the brunt of the thyrotoxicosis or toxemia. The symptoms of hyperthyroidism are often very mild, while the cardiac symptoms predominate, and little thought is given the adenoma as the causative factor.

There are two general theories regarding the toxicity in adenomatous goiter: Plummer<sup>30</sup> thought it was a pure hyperthyroidism, such as could be produced by the administration of dessicated thyroid extract, or thyroxin. The thyroid gland normally produces about  $\frac{1}{3}$  mg. thyroxin daily. If the adenoma is quiescent and does not produce any thyroxin, no symptoms of toxicity develop; if the adenoma becomes active and produces as much as  $\frac{1}{3}$  mg. of thyroxin daily and the thyroid rests, there still are no symptoms, but if the adenoma and thyroid are both active, toxicity ensues. Plummer also thought that as the adenomatous tissue becomes active it stimulates the surrounding tissue to hyperfunction.

Hertzler<sup>23</sup> and Chesky<sup>24</sup> have produced evidence to the effect that in a number of older patients with adenomatous goiter, all symptoms cannot be ascribed to a pure hyperthyroidism as produced by hyperplasia and hypersecretion. They contend that the toxemia is due to some change in the chemistry of the colloid. Early in the life of a colloid goiter, there is a gradual degenerative change in the colloid which produces an abnormal colloid having a deleterious effect on the heart, and can occur independently of any epithelial hyperplasia or simultaneously with it,

resulting in toxemia of degeneration, as well as hyperplasia.

We have noted that when toxicity develops in younger patients with adenomatous goiter, it simulates a true hyperthyroidism, in which the pulse rate is faster and the basal metabolic rate is higher than in older patients. It is remarkable how rapidly the cardiovascular system returns to normal following the enucleation of the adenomatous tissue. Toxic adenomatous goiters, as a group, do not respond to the preoperative administration of iodine in the same ratio as the exophthalmic group. Goetsch<sup>25</sup> stated that his results after the adoption of preoperative administration of iodine were no better than they were before; he ascribed this to the indiscriminate use of iodine in recent years. He continued to give iodine, however, and observed that the cases in which symptoms appeared only after taking iodine, or which were activated by it, were the most difficult to control. Goetsch is of the opinion that in such cases the iodine should be replaced by sedatives for one or two months, after which iodine may be given intensively for two to four weeks before surgical correction.

We have had the most favorable response in the younger group of patients who exhibit marked hyperactivity, with little or no degeneration in the gland, and with areas of hyperplasia, and who have not taken iodine previously. The majority of such cases have a reduction in the pulse and basal metabolic rates after the administration of 15 drops of Lugol's solution three times daily for two weeks. We have observed that the more hyperplasia there is present, the better the response to preoperative iodine medication.

Several observers have noted that a certain percentage of cases do not respond favorably to preoperative iodine medication. Lerman<sup>26</sup> found that patients over fifty years of age do not exhibit the same clinical remission to preoperative iodine medication as patients under that age. In a group of 706 patients, 96.6 per cent showed a favorable response, with an operative

mortality of 1.4 per cent, whereas in the 3.4 per cent which showed no response, there was a mortality of 24 per cent. The latter group of patients should have stage operations, the removal of the two lobes being separated by a rest of four to six weeks. Pole ligations are of no value in this type of goiter, as the superior thyroid vessels are not enlarged as compared to the exophthalmic type.

#### DIFFUSE TOXIC OR EXOPHTHALMIC GOITER AND IODINE

As mentioned above, Trousseau, in 1863, administered iodine, by mistake, in place of digitalis, to a patient with exophthalmic goiter, and noted beneficial results. Marine,<sup>7</sup> in 1907, observed that when iodine is given to a patient with a hyperplastic goiter, the follicles become distended with colloid and the gland enters a resting stage. Plummer was of the opinion that Grave's disease is evidently a dysthyroidism, and that the secretion is qualitatively abnormal, and excessive in amount. The normal hormone, thyroxin, is incompletely iodized, and the incomplete thyroxin, as it leaves the gland, enters catabolic reaction faster than the normal stable molecule and, therefore, raises the metabolic rate more rapidly. Administration of iodine changes the character of the molecule and iodizes it, rendering it normal, thereby reducing the metabolic rate and clinical symptoms. In 1923, Plummer<sup>27</sup> instituted the program of preoperative administration of 10 drops of Lugol's solution three times daily, with remarkable results. Within seven to fourteen days, in most cases, there was a marked clinical remission. There was also an immediate lowering of the operative mortality, with fewer postoperative crises and complications. This form of preoperative management was soon adopted by surgeons throughout the world. It was further shown by Plummer that the clinical remission would last from three to eight weeks. When the condition was not corrected surgically, the symptoms would

return to their former severity or become worse, even if Lugol's solution were given to tolerance. The patient is then robbed of his chance to be taken safely through an operation, for he is then "iodine fast."

All students of goiter agree that no frank case of hyperthyroidism is ever cured with iodine. It should be explained very carefully to the patient with an exophthalmic goiter that his case is surgical and that Lugol's solution is only used to prepare him for a safe operation. We never, under any consideration, prescribe Lugol's solution for a patient, unless the latter and his family understand that the drug is used for preoperative treatment, and definite arrangements are made for operation. It is explained to the patient that, as a rule, after a few days of iodine medication, the symptoms will subside or decline, and he may question the necessity of a thyroidectomy; but when improvement has reached a certain point, the surgery must take place.

Every goiter surgeon sees too many patients who have had Lugol's solution or other forms of iodine for months or years, until irreparable damage to the cardiovascular system and the liver has been done. Such patients often require stage operations and prolonged hospitalization in order to prevent excessive mortality. In patients who have had long continuous iodine medication, it is more difficult to evaluate properly the surgical risk. Lahey<sup>28</sup> has stressed this point for several years. When the patient is first seen, a preliminary evaluation of the risk is made; at no other time can this be done so advantageously. After bed rest, diet, sedatives and Lugol's solution, it is almost impossible to judge the proper time for operative interference without knowledge of the original status of the patient.

Mild cases of exophthalmic goiter are frequently encountered. Such cases should be observed until the diagnosis is definite; then they should be prepared with Lugol's solution and the condition corrected surgically. It is very unwise to give them a bottle



of iodine and let the disease progress until marked hyperthyroidism is present with cardiac damage.

Cases of recurrent hyperthyroidism are often found, following subtotal thyroidectomy for exophthalmic goiter. This occurs in about 3 per cent of any large group of cases studied. If the symptoms persist after the primary operation even in a mild form, the condition is termed persistent hyperthyroidism as differentiated from cases which develop symptoms of hyperthyroidism, from one to five years after the initial operation. These cases of recurrent hyperthyroidism can often be controlled by the prolonged administration of small doses of Lugol's solution; this is especially true of the disease in a mild form. Haines,<sup>29</sup> reporting from the Mayo Clinic, found that it is possible to control about 25 per cent of the cases of recurrent hyperthyroidism with prolonged administration of Lugol's solution. If the symptoms are severe and there is a large amount of hyperplastic tissue present, a secondary thyroidectomy will be necessary.

Although much time has been spent on educational work, iodine is one of the most misused drugs in the pharmacopoeia. There persists a too common belief, both among physicians and laity, that, given a goiter, regardless of type or activity, iodine medication must follow in one form or another. It is too often used when not indicated and wrongly used when indicated, with harmful results. It is sold over the counter in pills and ointments and is even advertised.

In order to confirm the impression that iodine is still widely misused, a questionnaire was sent to the members of the American Association for the Study of Goiter. While the author is cognizant of the danger of conclusions from questionnaires, based on broad and equivocal questions, he nevertheless, believes that the answers, particularly to the last questions are illuminating and valuable. Following are the results:

	Per Cent
1. Question: What form of iodine medication do you use in diffuse nontoxic (colloid) goiter?	
• Answer: Lugol's solution	50
Idostarine	16
Idostarine and thyroid extract	30
No treatment	4
2. Question: Do you treat mild cases of diffuse toxic (exophthalmic) goiter with iodine or advise surgery?	
Answer: Iodine only	4
Iodine followed by surgery, if necessary	8
Surgery with iodine preparation	88
3. Question: How long after surgery for diffuse toxic (exophthalmic) goiter do you recommend iodine administration?	
Answer: Two weeks after surgery	18
Three months after surgery	20
Six months after surgery	24
One year after surgery	32
4. Question: Are you generally able to control mild recurrent (not persistent) diffuse toxic goiter with iodine medication?	
Answer: No	55
Yes	45
(Seventy-eight per cent of the answers to this question stated that about 70 per cent of the cases of recurrent hyperthyroidism must have secondary operations.)	
5. Question: Do you advise iodine medication in nontoxic nodular (adenomatous) goiter in individuals twenty to thirty-five years of age?	
Answer: Yes	1
No (Advise surgery)	99
6. Question: Do you think that iodine medication produces toxicity in nontoxic nodular (adenomatous) goiter?	
Answer: No	21
Yes	79
7. Question:	
(a) What percentage of patients with toxic goiters coming to you for surgery have had previous iodine medication?	
(b) To what extent has this increased the operative risk and mortality?	
Answer:	
(a) Eleven per cent of physicians reported previous iodine medication for 0 to 25 per cent of patients.	
Thirty per cent of physicians reported previous iodine medication for 25 to 50 per cent of patients.	

## Per Cent

- Forty-eight per cent of physicians reported previous iodine medication for 50 to 100 per cent of patients.
- (b) Sixty-eight per cent of physicians report increased risk  
Seventy-eight per cent of physicians report increased morbidity  
Seventy-two per cent of physicians report increased mortality  
Eighty-four per cent of physicians report necessitated stage operations.

## SUMMARY

The answers to this questionnaire reveal that 96 per cent of the physicians suggest the use of iodine in the form of Lugol's solution (10 drops weekly) or one 10 mg. idostrone tablet weekly, alone or with dessicated thyroid extract in the treatment of colloid goiter.

Eighty-eight per cent find it necessary to correct mild diffuse (exophthalmic) goiter by subtotal thyroidectomy, and another 8 per cent suggest surgery if the condition is not cured in a reasonable period of time with iodine medication.

The opinion is practically unanimous (99 per cent) that nontoxic nodular (adenomatous) goiter should *not* be treated with iodine medication. As many as 79 per cent of the physicians agree that the promiscuous administration of iodine produces activation or toxicity in this type of goiter.

In toxic goiter, we note the greatest abuse in the use of iodine medication. Almost 90 per cent of the patients treated by goiter surgeons have had previous iodine medication, which produces an increase in the operative risk, and a very definite increase in the morbidity, especially since stage operations are often necessary in order to prevent an increased mortality. Practically all postoperative thyroid crises occur in patients who have had long continued iodine medication before consulting the goiter surgeon.

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THYROIDECTOMY in animals leads to retardation of growth which bears out a similar finding in children in whom there is a deficient thyroid function. The activity of the growth hormone of the pituitary is not dependent upon the presence of the thyroid but is greater when the thyroid is present. From—"Symptoms in Diagnosis"—by Jonathan Campbell Meakins (Little, Brown and Company).

# BURNS AND SCALDS

## THEIR ETIOLOGY AND PROGNOSIS

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*Introduction.* It is the purpose of this paper to discuss particularly the effect of etiology on the character of a burn, its clinical course and outcome. This study comprises 1,000 consecutive burn cases admitted to the Cook County Hospital between January 1935 and June 1937. Because of our small number of electrical and x-ray burns, we have stressed the literature on these types.

A few monographs and papers have been written on the relation of etiology to the prognosis of burns,<sup>13,14,15</sup> but they lie buried in the great mass of papers on therapy.

*Classification.* Burns have been classified according to penetration,<sup>8</sup> according to body areas involved<sup>1</sup> and according to etiological agents.<sup>3</sup> We shall here only consider the last.

Five etiologic types of burns are recognized: Thermal, light rays, electrical, roentgen ray and radium and chemical.

*Etiology.* Most burns are of accidental origin. However, in this series there were seventy-nine patients (forty-five colored and twenty-four white) who were deliberately burned. Boiling water was thrown on sleeping persons, dresses were intentionally ignited and chemicals were thrown into faces. They caused four deaths. There were four unsuccessful attempts at suicide by burning.

Predisposing factors which modify the character, course and outcome of a burn case are of five types:

1. *Age:* The average age of these 1,000 patients was twenty-eight years. The very young and the very old have poor tolerance to burns.<sup>13</sup> Infants have a delicate and

sensitive skin which reacts violently to even minor noxae. Maintaining them in adequate nutrition is often difficult. The aged are susceptible to the toxemia and the pulmonary and vascular complications of burns.

2. *Sex* plays a rôle. Women suffer more than men. Their dresses constitute a fire hazard, especially in the kitchen.<sup>13</sup> Their death rate was 1.5 per cent higher than that of the male. Pregnancy seems to confer some immunity during the third trimester. Three pregnant women received rather serious burns several weeks before term; they ran a mild course until delivery but all three then became increasingly ill and died within a few weeks postpartum with symptoms of a sepsis lenta.

3. According to Duke,<sup>14</sup> there exists allergy to heat. Certainly some people are burned more easily than others, and Pack<sup>13</sup> holds that skin thickness is not the sole factor. Burns are less serious in the negro and brunette "by virtue of their decreased visceral and sympathetic affection."<sup>13</sup> Our death rate was 11.1 per cent in colored and 14.0 per cent in white patients.

4. *Location:* Burns of the abdomen carry the highest mortality. Out of 110 total deaths the abdomen was involved in forty-six instances, or 41 per cent. Burns of flexor surfaces are more serious than of extensor surfaces. Burns of the genitalia, anterior chest wall and trigeminal area of the face produce most shock. Mucosal burns are more grave than cutaneous burns of equal area.<sup>14</sup>

5. *Concomitant infirmities* make the prognosis worse. Decreased pain and tactile sense make alcoholics, epileptics, tabetics

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and paralytics less sensible of injury. Thirty-five patients were burned in alcoholic stupor; eleven died, or 31 per cent. Of

Natural gas explosion burns rarely became infected in our series.

The "conflagration type" burns tend to

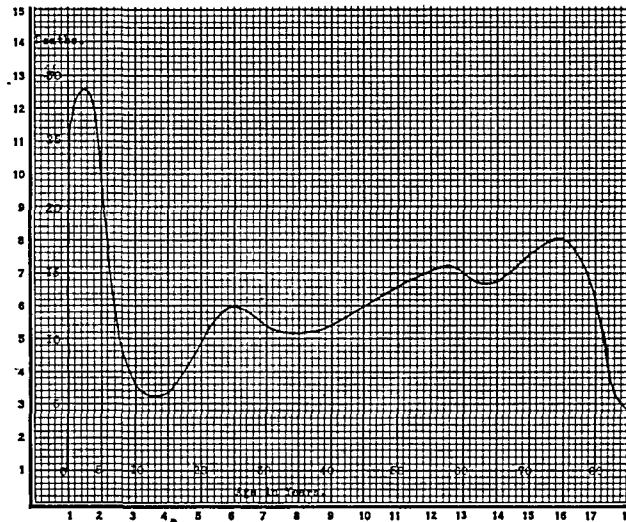


FIG. 1. The relation of age to death in burns.

twenty-five epileptics, one died; of four narcotic addicts and eight psychiatric patients, three died. Thus seventy-two patients, or 7.2 per cent of the total, had neural or sensorial lesions, 13.6 per cent of the total deaths.

*Burns Due to High (or Low) Temperatures.* According to Pack,<sup>13</sup> dry heat above 140°F. is required to produce a burn and moist heat above 125°F. to produce a scald. The better conductors of heat and the heavier liquids produce the more severe contact burns. Mucous membranes and peritoneum (hot laparotomy sponges) are more easily injured than skin.<sup>13</sup>

Flames caused 379 burns, subdivided into five groups. (Table 1.) Exposed parts of the body are involved first or exclusively. The modes of occurrence are listed in Table 1.

Gasoline burns came late to the hospital and presented a high incidence of complications, such as cellulitis and lymphangitis; scars and contractures made healing slow and painful and handicapped skin grafting.<sup>2</sup>

Kerosene burns are more prevalent in winter and among women, who are also the chief victims of cleaning fluid burns.

be extensive and fatal. The most serious are the alcoholic "bed smokers." Seventeen died. One night we had nine fatal "conflagration" cases from four fires, some with laryngeal and pulmonary edema from inhalation of smoke and gases.

Ninety-nine patients were scorched by various hot objects. These burns were usually on the exposed parts of the body. They were usually deep but small in area. The often long delay in seeking medical aid was reflected in a high incidence of infection. Deaths were a rarity.

Of the 305 patients with burns due to hot liquids, many were infants and young children. Infection was frequent, 113 or 37 per cent, too often due to the common home practice of smearing grease over the raw area.

Friction burns, due to abrasion plus heat, are said to be slow to heal.<sup>3</sup> We had none.

Twenty-four cases of frostbite are included in the series. They are so classified in some texts, probably because the tissue reactions to the two noxae—heat and cold—are similar.<sup>3,12</sup> Six cases of deep frostbite went on to gangrene of the fingers and toes and amputation with an average

TABLE I  
BURNS DUE TO TEMPERATURE CHANGES

[illegible]

TABLE I (Continued)

Burn Agent	Sex	Age	Color	Location	How Occurred	Time for Treatment, Hr.	Days in Hospital	Time of Year	Infection	Death	Complication	Skin Graft	Remarks
Frost bite	19 M. 5 F. 24	45	21 wh. 3 col.	Feet, hands	Exposure	48	27	Winter	9 (37%)	8 (33%)	2 (8%)	0 (0)	
Burns Due to Rays of Light													
Sunlight	9 M. 1 F. 10	20	10 wh.	Back, legs, arms, shoulders	Sunbathing	75	3	July	2 (20%)	0 (0)	2 (20%)	0 (0)	
Burns Due to Electricity													
Electric current	3 M. 1 F. 4	25	3 wh. 1 col.	All over	Touched live wire	40	13	Nov.	2 (50%)	0 (0)	2 (50%)	0 (0)	
Burns Due to Chemicals													
Chemical	35 M. 18 F.	27	36 wh. 26 col.	Face, eyes, mouth, hands, lips	Thrown on, ate, splashed on	36	8	All during year	5 (9%)	3 (5%)	22 (42%)	2 (4%)	
Burns Due to Miscellaneous Causes													
?	126	24	?	All over body	Not stated	Many old cases	38	.....	35 (28%)	9 (7%)	8 (7%)	45 (36%)	45 old cases returned for skin grafts
Totals and Averages													
	1000	28	.....	.....	.....	45	25	.....	333 (33%)	110 (11%)	140 (14%)	124 (12.4%)	

three months hospitalization. There were two very chronic cases of frostbite ulcers of several years' duration.

*Burns Due to Light Rays.* In the ten sunburn cases, delay in entering the hospital was the rule. The stay was short. The only complications were nausea, vomiting and dizzy spells. We had no burns from ultra-violet light apparatus.

*Electric Burns.* The local effects of electric currents seem due mainly to the heat generated in the tissues, dessication and charring. Bone, tendons, ligaments and calloused skin offer the greatest electrical resistance to the passage of the current and, therefore, theirs was the greater damage.<sup>6</sup> The point-of-contact burn may appear slight and yet a deep slough occurs even weeks later.<sup>6,7,10</sup> We noted no ventricular fibrillation or respiratory failure,<sup>10</sup> nor any central nervous system effects simulating cerebral concussion or traumatic psychoses.<sup>3</sup> There were no cases of late optic atrophy, central retinal atrophy or lens cataract.<sup>3,7</sup>

*Burns Due to Roentgen Rays and Radium.* Roentgen ray and radium burns are most stubborn.<sup>12</sup> We were fortunate to have only one. It was cured by excision of the ulcer from the abdominal wall with subsequent skin grafting.

*Burns Due to Chemicals.* Fifty-three patients had chemical burns, many of them limited to the face and mouth. Although the hospital stay was usually short, complications were many and, as compared to thermal burns, occurred late.<sup>11,15</sup> There were ten cases of corneal ulcers, four cases of keratitis and seventeen cases of chronic conjunctivitis usually due to some lye. Two late strictures of the esophagus in children were due to lye. A rodent ulcer developed in a deep acid burn of the face.

*Miscellaneous Series.* The miscellaneous series of 126 cases, in which the cause of the burn was omitted from the history record, came in for a large share of skin grafting. Forty-five of these patients were readmitted to the hospital for this reason.

Delay in seeking medical aid promotes infection. The average delay in this series was forty-five hours. Three hundred and thirty-three, or 33.3 per cent, of the 1,000 burns became infected either before entrance or during their stay, but of the 295 patients who arrived within three hours, only forty-one, or 13 per cent, became infected.

*Treatment.* We are not concerned here with the effect of treatment on burns. We believe that our therapy in these cases was sufficiently uniform so that the interesting results obtained can be ascribed chiefly to three factors: the etiology, extent and the elapsed time before starting hospital treatment of the burn. As a rule, the burn was first washed with soap and water and débrided until reasonably clean, dried and sprayed first with fresh tannic acid solution and then with silver nitrate.

*Prognosis.* There were 136 cases, or 13.6 per cent, that presented some complication. "Shock" was usual with extensive burns. In forty-four cases shock was stated as the cause of death which commonly ensued within forty-eight hours. In feeble patients, a minor burn sometimes precipitated profound and fatal shock. Convulsive seizures preceded a fatal outcome in five cases.

In fifty of the series, toxemia and sepsis from infected burns were considered responsible for death, usually during the second week. Vomiting was an ominous sign. Of forty-eight patients who vomited, forty-one died, and all of the twenty-seven patients with "brownish" or "rusty" emesis died.

There were nine cases of bronchopneumonia, three of uremia, one osteomyelitis of the wrist, one pulmonary embolus and two cases of bulbar palsy.

There were two cases each of erysipelas of the face, of pertussis and chicken pox, and one case each of measles, scarlet fever and impetigo. A fatal case of tetanus developed on the thirteenth day of a burn.

The death rate due to burns at this hospital has not changed appreciably in



the last five years, although plasma and blood transfusions have been freely used since 1937. The death rate averaged 11 per cent for the three years 1935, 1936 and 1937; 11.8 per cent for 1938, and 12.9 per cent for 1939. Table 1 tabulates deaths according to their causative agents. Graph 1 tabulates ages at death.

#### CONCLUSION

The prognosis of burns on a standard form of therapy depends partly on the etiologic factors involved. This is a prognostic factor which hitherto has been comparatively neglected in the literature of burns.

The author wishes to acknowledge his indebtedness to Dr. Roger T. Vaughan for his revision of the article.

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# SULLALLANTOIN IN THE TREATMENT OF WOUNDS

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**S**ULLALLANTOIN (p-amino benzene sulfonamide glyoxyldiureide) has been termed a loose addition product of sulfanilamide and allantoin, combining the bacteriostatic properties of the former substance with the cell-proliferating action of the latter. This new compound\* has been used locally in the form of a 2 per cent ointment in the treatment of twenty-five cases, including operative defects, decubitus ulcers and donor sites of skin grafts (Davis or pinch grafts).

Clinical observation indicates that the ointment has a soothing action and in most cases effects rapid improvement in the appearance of the wound. Two cases of irradiation necrosis involving the skin and subcutaneous tissues failed to show the usual rapid improvement, but the foul odor typical of such lesions soon disappeared and both patients stated that they were more comfortable. Neither local nor systemic reactions have been observed following the use of this ointment.

If necrotic or devitalized tissue is present, surgical débridement is essential. It is frequently desirable to irrigate the wound daily with  $\frac{1}{2}$  per cent chlorazene solution, normal saline or some other suitable agent.

Two particularly interesting cases treated with sullallantoin are described below:

**CASE 1.** W. H., a white male, aged sixty-six, was admitted to Jeanes Hospital March 31, 1941. At the age of four years, the patient fell into a bonfire and suffered severe burns of the buttocks and thighs. The burned areas healed slowly, with formation of a thick layer of scar tissue. At intervals of one and one-half to two years the scars on the buttocks became painful and ulcerated for a period of several

months, usually healing imperfectly with formation of fissures. An ulcerative lesion which had persisted in the scar of the left



FIG. 1. Squamous carcinoma arising in old burn scar of buttocks.

buttock for almost three years was excised in 1927 and the operative defect skin grafted successfully. In 1933, an ulcerative lesion in the scar of the right buttock was excised and the defect grafted. In October, 1939, the center of the scar became sensitive and extensive ulceration rapidly developed.

Multiple biopsy specimens contained squamous cell carcinoma. On April 11, 1941, the involved area was widely excised with the electric cutting current. Figure 1 shows the wound prior to operation. On the sixth postoperative day (Fig. 2) sullallantoin therapy was instituted. The ointment was applied each morning following irrigation of the wound with  $\frac{1}{2}$  per cent chlorazene solution. There was rapid improvement in the wound, and a healthy base of granulation tissue soon developed. Figure 3 shows the clean, granulating wound on the fourteenth postoperative day. On April 29, 1941, a Davis skin graft was carried out, using skin from the interscapular area. Sullallantoin ointment was applied daily to the donor sites, and all were completely healed within ten days. All of the skin grafts were successful and the operative area is in excellent

\*The Research Department of the Schuylkill Chemical Company, of Philadelphia, supplied the material necessary for carrying out this study.

condition. In view of the location of the wound, the result in this case was remarkably good.

CASE II. G. H., a white male, aged sixty-



FIG. 2 Appearance of wound on sixth postoperative day.

four, was admitted to Jeanes Hospital on December 27, 1941, with a history of bloody stools for a period of one year. Examination revealed an adenocarcinoma of the rectum. On January 21, 1941, a one-stage abdominoperineal resection of the rectum was carried out. Questionable invasion of the prostate necessitated wide excision anteriorly, and on February 8, 1941, a vesicoperineal fistula developed. The postoperative period was further complicated by a cellulitis of the lower abdomen and scrotum which necessitated incision and drainage of these areas. The patient's condition remained critical, and a large decubi-

tus ulcer appeared in the sacral region. On March 29, 1941, sulfallantoin ointment was prescribed and applied twice daily. Although



FIG. 3. Clean, granulating wound on the fourteenth postoperative day.

urinary drainage through the perineal wound persisted, the ulceration was almost completely healed after two weeks of sulfallantoin therapy.

#### SUMMARY

1. Encouraging results have been obtained in the treatment of twenty-five wound cases with sulfallantoin ointment.
2. No local or systemic reactions to the drug have been observed.
3. Ulcerations resulting from intensive irradiation are apparently not influenced by the drug.



# RETROPERITONEAL HEMORRHAGE\*

WITH SPECIAL REFERENCE TO THE ACCOMPANYING PARALYTIC ILEUS

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**R**ETROPERITONEAL hemorrhage may be of several varieties; it may be secondary to various etiological factors and is often difficult to recognize. It is invariably associated with a paralytic ileus. Any accumulation of blood found abnormally in the retroperitoneal tissues is considered a retroperitoneal hemorrhage. The condition may be trivial with such a small amount of hemorrhage that recovery occurs quickly and without serious complications. On the other hand, it may be quite serious and death may result within a few hours. The outcome usually depends upon the underlying etiological condition. (Fig. 1.)

The following classification, which was compiled from case reports in the literature, is presented and includes the various etiological conditions which predispose to retroperitoneal hemorrhage. (Table I and II.)

## TRAUMATIC

### a. Nonoperative:

1. Direct injury to muscle, kidney, blood vessel or other tissue situated retroperitoneally.
2. Fractures of the ribs, vertebrae or pelvis.

### b. Operative:

1. Secondary to any operative procedure related to the retroperitoneal tissues.

## NONTRAUMATIC

- a. Diseases of the blood vessels which are anatomically retroperitoneal: aneu-

rysm, spontaneous rupture of blood vessels associated with arteriosclerosis or hypertension.

- b. Diseases of the blood: leukemia and hemophilia most common.
- c. Diseases of the kidney: nephritis, hydronephrosis, calculi, cysts and neoplasms.
- d. Diseases of the retroperitoneal tissues: infections, neoplasms, embolic or thrombotic phenomena.
- e. No demonstrable cause: spontaneous hematoma unassociated with any demonstrable pathological condition.

Several unusual cases of retroperitoneal hemorrhage were observed at the Evanston Hospital and are presented in this report. In addition, seven cases of abdominal aortic aneurysm, which ruptured into the retroperitoneal space are submitted because of the interesting diagnostic problems present.

## CASE I. RETROPERITONEAL HEMORRHAGE OCCURRING AFTER APPENDECTOMY

Reference to retroperitoneal hemorrhage as a complication of an appendectomy could not be found in the literature. Because of the rarity of the condition and the surgical importance associated with the condition, the following case is presented:

Mr. E. H., aged thirty-nine, entered the Evanston Hospital on the service of Dr. F. Christopher for an interval appendectomy. A retrocecal appendix was removed through a McBurney incision which had to be enlarged slightly by cutting the upper transverse fibers of the internal oblique muscle. Otherwise the operation was uneventful. The immediate post-

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operative recovery was good. The pulse rate varied between 60 and 80. Six hours after operation the patient suddenly experienced a pain in his incision associated with nausea. The pulse rate ranged between 100 and 120. Blood pressure was 80 mm. of mercury systolic and 40 mm. of mercury diastolic. The skin was pale, cold and clammy. A diagnosis of postoperative hemorrhage was made and he was returned to the operating room. The incision was explored and a large retroperitoneal hematoma was evacuated. There was an estimated 500 to 600 cc. of blood in the retroperitoneal space. The bleeding point in the internal oblique muscle was ligated. No hemorrhage was found in the peritoneal cavity. The wound was closed with drainage down to the peritoneum and a transfusion was given. The postoperative course was stormy due to an intractable paralytic ileus secondary to the retroperitoneal hemorrhage. Gradually the ileus was overcome and the patient was discharged on the twelfth postoperative day.

The source of the retroperitoneal hemorrhage occurring in the above case was the lateral ascending branch of the deep circumflex artery. (Fig. 2.) This vessel is

regarded as the larger and terminal branch of the deep circumflex iliac artery and is situated about one inch from the anterior superior spine of the ilium. It ascends between the transverse and internal oblique muscles to about the level with the umbilicus. Two veins accompany this artery.

Undoubtedly this vessel has been encountered frequently during the course of an appendectomy through a McBurney's incision. However, its surgical importance has been limited to indicate the point of the intermuscular plane between the transverse and internal oblique muscles. Because of its position it is subject to trauma, thus ligation of this vessel when encountered is advisable.

CASE II. RETROPERITONEAL HEMORRHAGE OCCURRING AFTER A VAGINAL HYSTERECTOMY

Retroperitoneal hemorrhage developing by way of the broad ligament was observed in a patient who had undergone a vaginal hysterectomy.

TABLE I

NONTRAUMATIC GROUP (NO HISTORY OF TRAUMA AS A CAUSE OF RETROPERITONEAL HEMORRHAGE)

Author	No. of Cases	Diagnosis	Treatment	Result
Eiss <sup>3</sup>	1	Spontaneous perirenal hematoma	Operation	Recovery
Matheson <sup>5</sup>	1	Spontaneous retrocecal hematoma	Operation	Died
Marlow <sup>4</sup>	1	Spontaneous perirenal hematoma	No operation	Recovery
Bruce <sup>7</sup>	1	Spontaneous hematoma in hemophiliac	Operation	Died
Manizade <sup>8</sup>	1	Spontaneous hematoma in leukemia	Operation	Died
Cole <sup>6</sup>	1	Spontaneous retrocecal hematoma	Operation	Recovery
Bonar <sup>10</sup>	1	Ruptured abdominal aortic aneurysm	Operation	Died
Crile, Jr. <sup>9</sup>	1	Spontaneous rupture mesenteric vessel	Operation	Recovery
Polkey and Vynalek <sup>1</sup>	178*	Perirenal nontraumatic hematomas	47 no operation 62 nephrectomy 43 drainage	47 died 15 died 17 died
Karabin	7	Ruptured abdominal aortic aneurysm	3 operation	7 died

\* Collected cases.

Mrs. M. J., aged thirty-seven, entered the Evanston Hospital on the service of Dr. P. Schneider because of an early toxemia of pregnancy. The condition threatened her life, thus a therapeutic evacuation of the uterus was done. An attempt was made to sterilize the patient through a posterior colpotomy. During this procedure a vessel was accidentally torn and because of the persistent bleeding a vaginal hysterectomy was done. The patient went into shock but improved after several transfusions. The postoperative course was stormy. On the first day after operation the temperature was 104.6°F. The pulse rate was 130; the quality was poor. There was a marked pallor. A mass was found in the right lower quadrant of the abdomen which was thought to be a hematoma about the size of a grapefruit. On the second postoperative day the abdomen was distended and Wangensteen suction was instituted. The patient was very toxic due to the intractable paralytic ileus. On the fifth postoperative day there was a profuse vaginal discharge of old blood and a decrease in the size of the hematoma. The distention of the abdomen gradually diminished with the evacuation of the hematoma. The patient made a gradual recovery and was discharged thirty-eight days after operation.

The underlying causes of her stormy postoperative course were no doubt the

retroperitoneal hemorrhage and operative shock. Improvement occurred concurrently with the spontaneous evacuation of the hematoma. Fortunately, it was not necessary to drain the hematoma surgically for any additional injury might have been fatal.

The following seven patients died of an aortic abdominal aneurysm which had ruptured retroperitoneally:

CASE III. J. R. C., aged fifty-four, a white male, presented a history of severe backache and generalized abdominal pain which occurred while working. He had vomited once. He collapsed and was seen by a physician who found a blood pressure of 160 mm. of mercury systolic and 110 mm. of mercury diastolic. Further findings at this time were essentially normal. He was then removed to the Evanston Hospital whereupon entrance, three hours after the onset, a blood pressure of 230 mm. of mercury systolic and 140 mm. diastolic was recorded. One-half hour after entrance to the hospital he again collapsed and a blood pressure of 80 mm. systolic and 60 mm. diastolic was found. The pulse rate varied from 86 to 100. At this time there was marked pallor. His pain was now referred into the suprapubic region and the abdomen was found to be tender over a mass situated between the iliac crest and the

TABLE II  
TRAUMATIC GROUP (TRAUMA AS A CAUSE OF RETROPERITONEAL HEMORRHAGE)

Author	No. of Cases	Diagnosis	Treatment	Result
Bonar <sup>10</sup>	1	Traumatic hematoma; melanosis of kidney found one year later	Operation	Died
Cole <sup>6</sup>	3	1. Fractured ribs and kidney trauma 2. Bullet wound of kidney 3. Fracture 4th L. Vert.	Operation Operation Operation	Recovery Died Recovery
Christopher <sup>12</sup>	1	Fractured ribs	Operation	Recovery
Eiss <sup>3</sup>	1	Traumatic hematoma	Operation	Recovery
Hinton <sup>11</sup>	19	17 traumatic rup. kidney 2 traumatic hematoma without kidney injury	17 no operation 2 operations	16 recovered 1 died 1 died
James <sup>20</sup>	1	Traumatic hematoma	Operation	1 recovered
Neller <sup>21</sup>	2	Fractured pelvis	Operation	Recovery
Susman <sup>22</sup>	1	Traumatic hematoma	Operation	Died
Karabin	2	1. Postappend. 2. Postvag. hysterectomy	Operation No operation	Died Recovery Recovery

costal margin. He continued to vomit through the night but on the next day he seemed to be improved except for persistent hiccoughing.

tests were negative. Upon examination the temperature was 98.6°F.; the pulse rate was 80 and of good quality. The blood pressure was

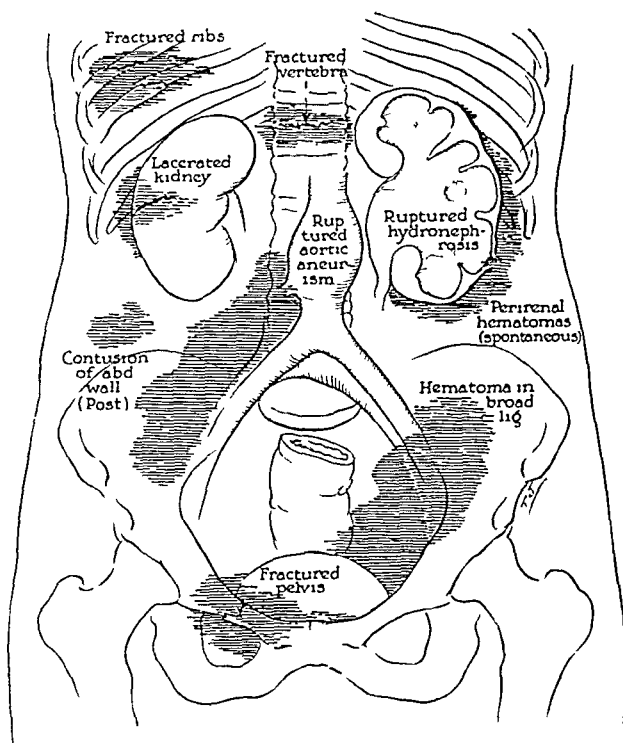


FIG. 1. Diagrammatic illustration of the common etiological factors in retroperitoneal hemorrhage.

The abdomen was distended. On the second day he suffered another attack of colicky pain in the left side of the abdomen and again suddenly collapsed. The patient was in severe shock and did not respond to the usual methods and died. A diagnosis of an intra-abdominal hemorrhage was made but no cause was known. The Kahn test was negative. Postmortem examination revealed an abdominal aneurysm which had ruptured into the retroperitoneal space. There was a marked generalized arteriosclerosis which was probably the basis for the formation of the aneurysm.

**CASE IV.** W. A. P., aged eighty-two, a white male, presented a history of abdominal pain for forty-eight hours which was referred to the right leg. Twenty-four hours after the onset of the disease he was nauseated and had vomited many times. The vomitus was of a bilious character. There was no past history of similar attacks although he had complained of some pains in his legs for ten days prior to his admission. He stated that he had had an abdominal aortic aneurysm for about four years but was never troubled by it. Serological

142 mm. of mercury systolic and 92 mm. of mercury diastolic. A pulsating tender mass situated in the midline between the umbilicus and pubis was about the size of an orange. A bruit was heard over the mass. There was rigidity and tenderness in the right lower quadrant and rebound tenderness was elicited. A diagnosis of appendicitis was made and under local anesthesia a normal appendix was removed. No definite cause for the patient's distress could be found but a retroperitoneal hemorrhage was suspected. The postoperative course was stormy primarily because of a severe paralytic ileus. The patient continued to get weaker. The pulse rate increased to 110 and became weak and irregular. He died on the third day postoperatively, six days after the onset of the disease. Postmortem examination revealed an abdominal aortic aneurysm which had ruptured into the retroperitoneal space. There was an associated generalized arteriosclerosis.

**CASE V.** P. L., a seventy-three year old white male, entered Evanston Hospital with a history of a generalized lower abdominal pain

for four days. The pain was not localized or referred and was a severe, constant aching pain. He had vomited several times. There was no

male, entered the Evanston Hospital with a history of sudden, severe, abdominal pain occurring at 2 A.M. He collapsed and following

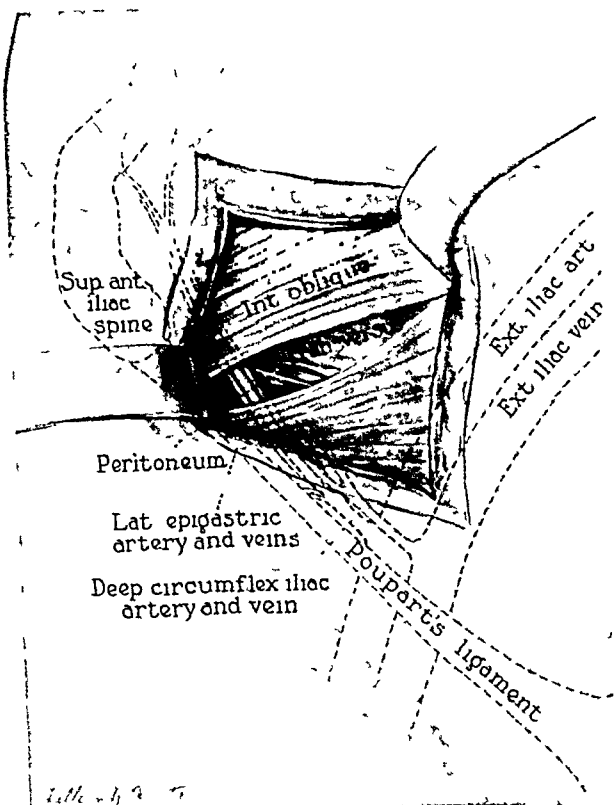


FIG. 2. Illustrates the relationship of the lateral ascending branch of the deep circumflex iliac artery which may be encountered in a McBurney incision. This vessel was the source of serious retroperitoneal hemorrhage following an appendectomy in Case 1.

past history of any similar attacks of pain. Upon examination the blood pressure was 120 mm. of mercury systolic and 85 mm. of mercury diastolic. The pulse rate was 60 with regular rhythm and of good quality. The entire abdomen was rigid. Just below and to the right of the umbilicus was a tender, pulsating mass. A bruit was heard over the mass. A diagnosis of aortic aneurysm was made and confirmed by X-ray of the abdomen. (Fig. 3.) The plate showed an ovoid mass in the midline with calcified walls. There was no erosion of the lumbar vertebrae in the lateral view of the spine. The urine showed gross blood. He was treated conservatively and on the third day after admission and seven days after the onset of the disease he suddenly collapsed and died. No postmortem examination was done. The clinical diagnosis was a ruptured aortic aneurysm into the retroperitoneal space.

CASE VI. F. W., a sixty-four-year old white



FIG. 3. X-ray plate of the abdomen illustrating an abdominal aortic aneurysm. Arrows point to the wall of the aneurysm which shows up largely because of the calcification (Case v).

this developed a marked pallor. There was no vomiting. The past history was negative. He had a known hypertension for several years. The Kahn test was negative. Physical examination revealed a somewhat stuporous, markedly pale patient with a pulse rate of 90 of fair quality. The blood pressure was 60 mm. of mercury systolic and 40 mm. of mercury diastolic. The abdomen was moderately tender and rigid in the right lower quadrant. There were no palpable masses. No definite diagnosis could be made; thus, an exploratory laparotomy was done. Exploration revealed an abdominal aortic aneurysm which had ruptured retroperitoneally. The aneurysm was not disturbed and the abdomen closed. The immediate postoperative condition was good except for a moderate abdominal distention. On the first postoperative day he complained of severe backache. The pulse rate was 118 and of fair quality. On the second day and three days after the onset of the disease he developed a sudden severe pain in the back referred to the



right lower quadrant and then collapsed and died. Postmortem examination confirmed the operative findings of an abdominal aneurysm which had ruptured retroperitoneally. There was a marked generalized arteriosclerosis.

CASE VII. W. J., aged seventy, had suffered a sudden severe knife-like pain in the right lower quadrant of the abdomen while lifting a heavy object. He became weak and pale. The pain was referred to his right leg. There was no nausea or vomiting. The past history was essentially negative. He entered the Evanston Hospital twenty-four hours after onset in profound shock. The pulse rate was 92 and weak in quality. The abdomen was distended and tender in the right lower quadrant. A soft, pulsating mass about the size of an egg was found just to the right of the umbilicus. A diagnosis of aortic aneurysm and a possible appendicitis was made. An exploratory laparotomy was done which revealed a retroperitoneal hematoma from a ruptured abdominal aneurysm. The pain persisted postoperatively and the pulse became weaker. He died suddenly on the first postoperative day, three days after the onset of the disease. Postmortem examination confirmed the operative findings.

CASE VIII. J. W. B., aged sixty-nine, gave a history of pain in the lower abdomen, cramp-like and not referred. He had been well until twelve hours before entrance to the Evanston Hospital. Soon after the pain developed he collapsed and developed a marked pallor. Physical examination revealed a blood pressure of 122 mm. of mercury systolic and 82 mm. of mercury diastolic. The pulse rate was 80 and of poor quality. The patient was stuporous. The abdomen was rigid and tender in the lower half. There were no palpable masses. The pain became worse and was referred into the left leg. Singultus was marked. The abdomen became distended and he collapsed and died forty-eight hours after the onset of the disease. Postmortem examination revealed an abdominal aortic aneurysm which had ruptured into the retroperitoneal space. There was a marked generalized arteriosclerosis.

CASE IX. L. E. B., eighty years of age, entered the Evanston Hospital with a history of severe epigastric pain of twenty-four hours' duration which was referred to the back. There was considerable vomiting and hiccoughing. There was no history of previous attacks.

Examination revealed a pulse rate of 80 of fair quality. The blood pressure was 140 mm. of mercury systolic and 90 mm. of mercury diastolic. The abdomen was distended. Tenderness was present in the epigastrium. In the left upper quadrant there was a pulsating mass which was thought to be an aortic aneurysm. However, because of the persistent pain and tenderness an exploratory laparotomy was done. At operation an abdominal aortic aneurysm which had ruptured into the retroperitoneal space was found. The abdomen was closed without disturbing the hematoma. The patient died suddenly twenty-four hours after operation and three days after the onset of the disease. A postmortem examination confirmed the operative findings. There was a generalized arteriosclerosis.

The clinical findings in patients with an abdominal aneurysm ruptured retroperitoneally are quite similar to the signs and symptoms of retroperitoneal hemorrhage from other causes. The onset of the attack occurs with a sudden pain without any history of previous similar attacks. The abdominal pain may be generalized or localized to either side in the lower abdomen or referred into the legs. Back pain is a frequent complaint. At varying intervals (few minutes to several hours) after the onset of pain the patient feels faint and collapses. Following the collapse there is usually a marked pallor. The blood pressure is low and the pulse rate rapid. A mass may be palpable. The abdomen is rigid and tender at the onset, but as the disease progresses the rigidity usually diminishes and an ileus develops. The ileus may appear from twenty-four hours to five days after the onset of the hemorrhage. This distention is frequently marked and does not respond to usual methods of treatment. A bruit is often heard over the aneurysm but not always heard over a hematoma resulting from a rupture of an aneurysm. Severe vomiting and hiccoughing are often present. The laboratory findings are of no diagnostic value early in the disease but later an anemia may develop. Serological tests are usually negative.

The most valuable procedure in the diagnosis of an abdominal aneurysm is an x-ray examination of the abdomen. As in patient P. L. (Fig. 3) an x-ray plate of the abdomen revealed an aneurysm which at the onset of the disease was not palpable because of the abdominal rigidity. Kampmeir<sup>2</sup> found that the x-ray examination was positive in 75 per cent of the cases and that 50 per cent of the cases showed a pressure erosion of the bodies of the vertebrae without destruction of the intervertebral discs which is pathognomonic of abdominal aneurysm. Farmer<sup>23</sup> suggested a pneumoperitoneum be produced in order to outline the aneurysm as an aid in its diagnosis, however, this procedure does not seem necessary, for ordinarily a lateral and anteroposterior view will suffice. (Fig. 3.)

The prognosis in ruptured abdominal aortic aneurysm is poor. Death usually occurs within six months after the discovery of the condition. Death occurs from hemorrhage as a result of a rupture of the aneurysm, usually retroperitoneally. Surgical intervention such as wiring has been tried with little success for complete cure. Recently Bigger,<sup>24</sup> Elkin<sup>25</sup> and Matas<sup>26</sup> have presented encouraging results in the treatment of aneurysm of the abdominal aorta by ligation.

The findings presented by patients with a perirenal nontraumatic hematoma are quite similar to those in ruptured abdominal aortic aneurysm. Polkey and Vynalek<sup>7</sup> found that the most common signs and symptoms found in these patients were pain in the region of the kidney, palpable tumors and signs of hemorrhage. With a palpable tumor or dullness in the flank which progressively increased in size and was associated with signs of hemorrhage, one could almost be sure of a diagnosis of retroperitoneal hemorrhage. Nausea, vomiting, meteorism and ileus were not uncommon. Death usually occurred from secondary anemia, ileus, pneumonia, sepsis, uremia or operative shock. In the treatment of the condition they found that of the forty-seven patients treated conserva-

tively, there was a 100 per cent mortality. When nephrectomy was done the mortality was 24 per cent and when drainage alone was instituted the mortality was 40 per cent. Such findings would indicate that the method of choice was a nephrectomy.

The signs and symptoms of patients in traumatic retroperitoneal hemorrhage are not unlike those presented in the non-traumatic group. Exploratory laparotomy may often be necessary because of the inability to differentiate the condition from perforation of a viscus. The treatment of patients in this group varies considerably. Hinton<sup>11</sup> advocates conservative treatment in traumatic rupture of the kidney with retroperitoneal hemorrhage. He treated seventeen such patients conservatively with sixteen recoveries. Cole<sup>6</sup> explored three patients with traumatic retroperitoneal hemorrhage which simulated a generalized peritonitis. Two of these patients recovered.

The prognosis in any patient with retroperitoneal hemorrhage must be guarded. The underlying cause of the hemorrhage will determine in most cases the outcome of the disease. In any case, the presence of blood in the retroperitoneal tissues must be considered as a serious problem.

Paralytic ileus as a complication of retroperitoneal hemorrhage is not uncommon. Lenormant and Cordier<sup>13</sup> emphasized the importance of ileus as a complication in such patients and presented various etiological factors. Eight of the nine patients presented in this report developed an ileus. When an intractable ileus develops following traumatic retroperitoneal hemorrhage, it is often necessary to do an enterostomy. No doubt the procedure to be followed will depend primarily upon the etiological factor and the judgment of the attending physician.

The fact that blood in the retroperitoneal space was an irritant was proved experimentally by Guibal and Cuenot.<sup>14</sup> Tixier and Clavel<sup>15</sup> studied the relationship of the retroperitoneal syndrome to the gastrointestinal reflex from the kidney. A reflex,

the renodigestive, was demonstrated, and a syndrome simulating a peritonitis was developed experimentally by stimulation of the kidney and retroperitoneal tissues. They could not conclusively explain the mechanism of the reflex but suggested that it involved several factors. It was either a summation of the irritating impulses, an individual predisposition or a sensitization of nerve centers through an infection or intoxication. This syndrome was observed in the above patients during the acute stage of the retroperitoneal hemorrhage and was no doubt due to a reflex as suggested. Cole<sup>6</sup> also observed such patients with a so-called retroperitoneal syndrome simulating a peritonitis and thought it was a reflex through irritation of the sympathetic nervous system.

Considerable controversy as to the mechanism of this reflex has been found in the literature. The majority believe that the reflex occurs through the irritation of the splanchnic nervous system, as first advocated by Starling.<sup>16</sup> However, further evidence suggests that the mechanism involves the parasympathetic system as well as the splanchnic system. Kuntz<sup>17</sup> presented the following facts concerning the gastrointestinal physiology: Bilateral section of the vagi above the diaphragm resulted in a diminution in the tonus of the gastrointestinal musculature and retardation of peristalsis. However, both tonus and peristaltic activity were soon restored to the condition which existed before vagotomy. Bilateral section of the splanchnic nerves increased the tonus and augmented peristaltic activity. This also subsided in a relatively short time and was often followed by a hypotonic condition. However, section of both the vagus and the splanchnic nerves resulted in a marked hypotonicity of peristalsis. Apparently the splanchnic system exerted an inhibiting action which overcame the stimulating action of the parasympathetic system. This condition was of longer duration. Such evidence indicated that the motor and inhibitory impulses to the gastrointestinal tract were

conducted through the sympathetic and parasympathetic systems with equal facility. To support this contention, Graham and his associates<sup>18</sup> studied the reflex of vomiting in peritonitis and found that the reflex impulses traveled through either system and that only through section of both systems could the reflex be abolished. Thus, one may surmise that the mechanism of the reflex from the retroperitoneal hemorrhage developing at the onset of the disease occurs through irritation of both systems and not the sympathetic system alone. After a retroperitoneal hemorrhage, a paralytic ileus develops as a late sign of the irritation of the retroperitoneal tissues. The ileus occurs from twenty-four hours to five days after the onset of the disease.

That the ileus is due to paralysis of the sympathetic and parasympathetic nervous systems was suggested by Walton<sup>19</sup> and is supported by the clinical evidence in the patients presented in this report. The ileus is severe and does not respond to ordinary measures until the paralyzing effect of the retroperitoneal hemorrhage is removed. The paralysis is temporary and not unlike the transient paralysis of nerves due to hematomas which occur in other parts of the body. Although no positive proof can be given to the above mechanism of the ileus, it seems that the clinical picture presented by patients with an ileus associated with retroperitoneal hemorrhage can be better explained upon the basis of a temporary paralysis of the sympathetic and parasympathetic systems, rather than a reflex through the splanchnic system alone.

The treatment of such an ileus is directed at the cause. Removal of the irritating hematoma is desirable but often difficult. When this is impossible it may be necessary to relieve the ileus by an enterostomy. If the patients can be treated conservatively without endangering their life because of toxicity or starvation, such a procedure should be followed. The prognosis varies and depends upon the underlying cause.

## SUMMARY

Nine patients with retroperitoneal hemorrhage are reported. One hemorrhage occurred after an appendectomy, another after a vaginal hysterectomy, and seven as a result of a ruptured abdominal aortic aneurysm.

Retroperitoneal hemorrhage may be classified into hemorrhage due to non-traumatic and traumatic causes. The signs and symptoms are quite similar in both groups but may vary with the underlying cause of the hemorrhage.

The treatment of the retroperitoneal hemorrhage will depend upon the etiology of the condition.

At the onset of the hemorrhage there is an abdominal syndrome simulating a generalized peritonitis and is due to a reflex, most likely from an irritation of the sympathetic and parasympathetic nervous systems.

After this acute stage, a paralytic ileus usually develops. The ileus may occur from twenty-four hours to five days after the onset of the hemorrhage. It is probably due to a paralysis of the sympathetic and parasympathetic systems, rather than a reflex irritation of the splanchnic system.

The prognosis in patients with retroperitoneal hemorrhage will vary and depend entirely upon the etiology of the condition.

I am grateful to Doctors R. Blessing, F. Christopher, J. P. Grier, W. R. Parkes, P. Schneider and H. O. Weishaar who have kindly allowed me to use the above case reports.

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# INGUINAL HERNIA

## A NEW CONCEPT AND OPERATION

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THE Ancient Egyptians knew of the existence of hernia; the Greeks had a significant word for it based on the word *Épvos*, a branch or outgrowth; the modern Anglo-Saxons gave hernia a different implication and considered it a rupture; the Teutons called it a break (Bruch). Contemporaneously this conception of tear or break is no longer tenable, it being generally agreed that the condition is indeed an outgrowth of peritoneum, which outgrowth, however, is always congenital. This applies only to an indirect hernia.

To clarify the nomenclature, it might here be interpolated that a differentiation must be made from the conception of the congenital nature of inguinal hernia as entertained about twenty-five years ago when only such hernias were considered congenital in which the testicle was contained within the hernial sac, i.e., the hernial sac and the tunical vaginalis being one and continuous.

If, however, the present day belief is correct that all indirect inguinal hernias are congenital, how can we explain the fact that the clinical manifestations of hernia, that is, the descent of abdominal viscera into the sac usually occurs for the first time only in adult life? There are only two deductions: (1) that the congenital theory is incorrect, or, (2) that the mechanism has broken down by which the abdominal contents had been prevented from entering the sac. I am definitely inclined toward this latter hypothesis. This mechanism, the inguinal valve, if I may coin the term, is dependent upon three factors: (1) a small internal ring; (2) an obliquity of the inguinal canal passing at different levels through the abdominal wall; (3) a proper

functioning, sliding door closure of the internal oblique muscle. This is accomplished when its contraction straightens and shortens its own arched line, thus tending to cover over and protect the internal ring.

The inadequacy of this inguinal valve may be due to three causes: (1) an enlargement of the internal ring, which thereby approximates the external ring and thus, (2) converts an oblique canal into an almost vertical one; (3) anatomical muscular deviations: (a) congenital, the further away from the anterior superior spine of the ilium the muscle takes its origin the less protection it can afford the internal ring, (b) acquired, general debility with weak muscular contraction; (4) increased intra-abdominal pressure from tumor, fluid, etc. Whether intra-abdominal pressure can be sufficiently increased by external violence to break down the inguinal valve, is very doubtful.

*Fallacy of Most Operative Repairs.* Suture of the muscle to Poupart's ligament, the *sine qua non* of the Bassini operation with the idea of building up the floor of the hernial canal is illogical. First, there is no weakness of the floor; second, nowhere in the human economy is muscle structure used as a fixed buffer state, it having only four functions, motion, locomotion, sphincteric control and stabilization; third, muscular fixation is bound to result in atrophy of disuse and thus, when and if the suture gives way, the muscle is weaker than before operation, with the recurrence often larger than the primary hernia.

In an attempt to re-establish physiological normalcy and to overcome some of the operative fallacies, I have been using the fol-

\* From the Surgical Service of the Hospital for Joint Diseases, Dr. Bodenheimer and Dr. Beller.

lowing technic for the past five years, the detailed operation having been reported in a previous article:<sup>1</sup> (1) eradication of the

first type may become incarcerated or strangulated, the latter never. I have seen two such cases. In the former, the sac must

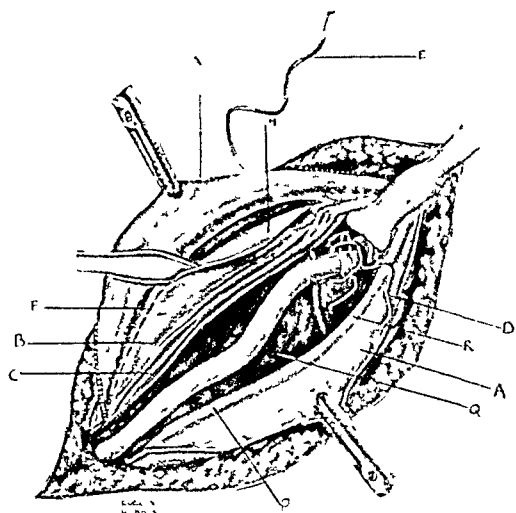


FIG. 1.

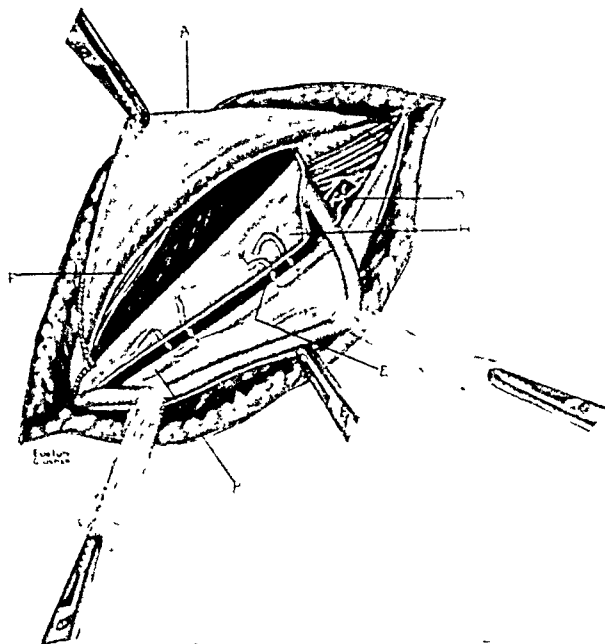


FIG. 2.

FIGS. 1 AND 2. A, aponeurosis external oblique muscle; B, aponeurosis internal oblique muscle; C, internal oblique muscle; D, suture through internal ring; E, fascial suture; F, incision of aponeurosis internal oblique muscle; H, flap of internal oblique aponeurosis; P, Poupart's ligament; Q, transversalis fascia; R, deep epigastric vessels.

sac; (2) narrowing of the internal ring with one to three mattress sutures taken at the cephalad rather than at the caudal quadrant of the ring, so as to avoid injury to the deep epigastric vessels; (3) placing the internal oblique muscle in better functioning position, never by passing sutures through the belly of the muscle but by incising the fascia of the internal oblique muscle, and suturing the ensuing lateral edge to Poupart's ligament with interrupted mattress sutures. Mattress sutures are used so as to give wider apposition. Transplantation of the cord seems of little moment.

*Direct hernias* have two clinical types: one in which there is an actual opening in the transversalis fascia through which a definite peritoneal pouch or sac protrudes, and a second type in which there is a relaxation of the transversalis fascia permitting a general bulge. Preoperatively they cannot be differentiated. Their relative importance lies in the fact that the

be eradicated, the neck transfixated and the opening in the transversalis fascia closed; in the second type the transversalis fascia is exposed well posteromedially to the internal oblique muscle, incised without opening the peritoneum and its cut edge together with the cut edge of the fascia of the internal oblique, sutured to Poupart's ligament.

It is my impression that in the direct hernias, better contact is obtained and less tension occurs at Hasselbach's triangle by transplanting the cord subcutaneously or subaponeurotically. Good exposure, especially, at the pubic spine, is essential.

In the first series of cases, fascial strips were taken from the external oblique aponeuroses and reinforced by catgut. Fascia lata was utilized only in the recurrent cases in which previous infection had destroyed the external aponeurosis.

A second series of cases has been started in which fine silk is being used throughout, but sufficient time has not yet elapsed to warrant a report.

## STATISTICS

	10-20	21-30	31-40	41-50	51-60	61-70	Operations
Indirect	8	19	16	19	15	15	82
Direct	0	4	15	12	10	6	47
Indirect-direct		3	2	4	2		11
Recurrent, indirect		3	1	1	3	1	9
Recurrent, direct		1	3	2			6
Recurrent, indirect-direct				1			1
Recurrent, Spiegel				1			1
Total patients	8	30	37	40	30	12	157

## TIME SINCE OPERATION, YEARS

	7	6	5	4	3	2	1	Patients
Indirect	2	7	8	22	11	19	10	79
Direct	2	1	3	7	7	5	12	37
Indirect-direct			1	2	1	1	1	6
Recurrent			2	2	7	3	2	16
Total	4	8	14	33	26	28	25	138

## Types

	Number
Indirect	82
Direct	47
Indirect-direct	11
Recurrent, indirect	9
Recurrent, direct	6
Recurrent, indirect-direct	1
Recurrent, Spiegel	1
Total	157

## Age

Second decade	8
Seventh decade	12
Fifth decade	40
Third, fourth, sixth, each about	32

## Sex

Males	133
Females	4

## Recurrences

## Primary:

Indirect: 1.4 per cent
82 hernioplasties, 71 follow-up, 1 recurrence
Direct: 11.7 per cent
43 hernioplasties, 30 follow-up, 4 recurrences
Indirect-direct: 12.5 per cent
11 hernioplasties, 8 follow up, 1 recurrence

## Secondary:

Indirect: .0 per cent
Direct: 7.4 per cent
17 hernioplasties, 14 follow-up, 1 recurrence.

## CONCLUSIONS

An attempt has been made to place inguinal hernioplasty upon a rationalistic basis.

Whether the author's enthusiasm is justified, can be determined only by time and usage.

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# Case Reports

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## A MODIFIED APPROACH IN SURGERY FOR TUBERCULOSIS OF THE ELBOW IN THE ADULT\*

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AT the onset, the author wishes to emphasize two points: (1) that the paper is restricted to consideration of tuberculosis of the elbow in adults only, and (2) that ankylosing operations for tuberculosis of the elbow in adults have been disappointing in their end results insofar as obtaining fusion is concerned.

The writer carried out a review of recent literature covering this subject and he has been left with the belief that the majority of surgeons by far favored excision of the elbow and that the treatment was definitely away from arthrodesing operations for the purpose of obtaining a cure and arrest of the tuberculous process. This situation appears to be particularly well illustrated by the remarks of Buzby<sup>1</sup> who states "Tuberculosis of the elbow seems the only condition where all are in accord that excision is the operation of choice."

Cleveland<sup>2</sup> reports five cases in which an arthrodesing operation was carried out. Of these, one resulted in bony fusion, two others resulted in pseudoarthrosis but became quiescent. In 1939, his reactions were definitely in the direction of resection considering the poor results obtained from any arthrodesing operation. Macausland<sup>3</sup> is of the same opinion.

Erlacher<sup>4</sup> described one case of tuberculosis of the elbow in which a radical extirpation of the tuberculous focus was carried out. Since this did not penetrate into the

elbow joint it cannot be included in this study.

Steindler,<sup>5</sup> Campbell,<sup>6</sup> and Hallock<sup>7</sup> all report cases of attempts at operative fusion. All these were of the extra-articular type. Steindler used a tibial graft. Campbell described a procedure using an osteoperiosteal graft. However, he stated that he advised joint resection.

The writer has used the olecranon as the graft material in the three cases reported below. Hallock<sup>7</sup> described several cases in which the olecranon had been used but the writer believes that the disposition and the placement of this graft vary in certain essential details. In fact, the author is of the opinion that these variations have been definitely contributory to the good end results obtained in the cases described below.

It was believed at the time of operation that heretofore the graft had not been placed sufficiently securely into both ulna and humerus to obtain a good purchase on healthy bone above and below the elbow joint, and that this inability to hold the graft firmly in its prepared bed, so as to secure immobilization, has contributed toward unsuccessful attempts to secure fusion.

Thornton<sup>8</sup> described one case in which he used both olecranon and the proximal portion of the ulna as an inlay graft across the joint line. However, this type of graft, we

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believe, would be difficult to place into the elbow in any other position but extension. By using the technic described below,

*olecranon are spared and remain intact on both sides.* This portion of bone is gently elevated with the proper instrument until it

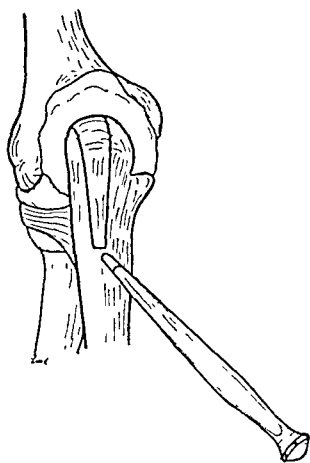


FIG. 1. A slightly wedge-shaped portion of bone is outlined on the olecranon and ulna with a thin osteotome.

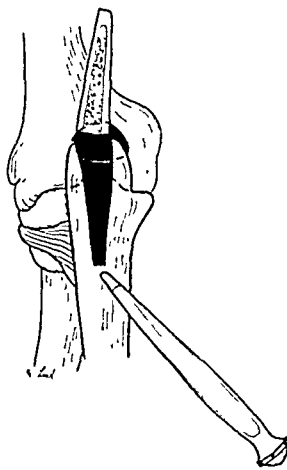


FIG. 2. The portion of olecranon is gently elevated with the proper instrument until it lies free but is still attached to the triceps.

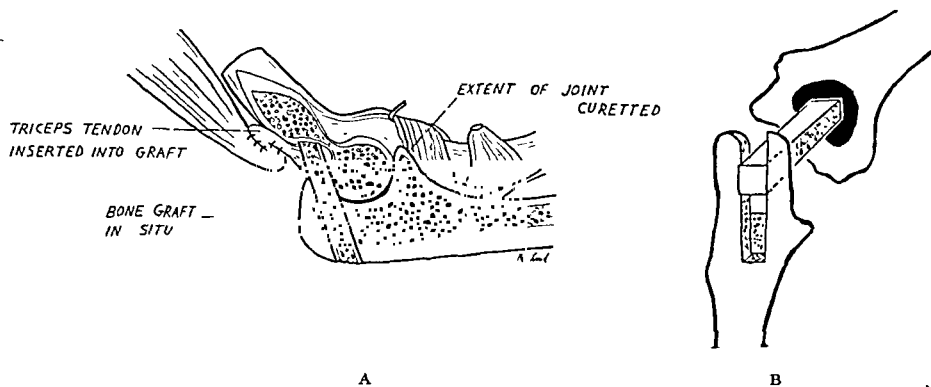


FIG. 3. A, insertion of graft. B, diagrammatic sketch to illustrate the position of the graft.

the graft fits just as well in any angle which would be comfortable for the patient.

#### OPERATIVE TECHNIC

With the patient lying supine and the elbow laid across the chest, a midline, posterior incision is made extending from above to four inches below the elbow with the olecranon tip about midway. The triceps and subcutaneous portion of the ulna are exposed in the midline. With a thin osteotome, a slightly wedge-shaped portion of bone is outlined on the olecranon and ulna. (Fig. 1.) *Both lateral walls of the*

*lies free but is still attached to the triceps.* (Fig. 2.) A portion of the triceps tendon, corresponding in width to the graft which is to be used, is mobilized by two longitudinal incisions so that the graft and its attached tendon may be elevated *en masse* proximally. The elbow joint comes into view and as much diseased tissue as possible is curetted away. With this approach the ulnar nerve is well protected and does not come into view during the course of the entire operation since it has been retracted with the other soft tissues. The olecranon fossa is "fish-scaled" in its preparation for

the reception of the graft which is inserted. (Fig. 3A.) It will now be seen that the walls of the olecranon obtain a purchase on the

Hospital for symptoms referable to the left elbow. The patient stated that he had been suffering from pain in that joint since 1936.



FIG. 4. Case 1. Preoperative x-ray.

graft and tend to hold it as by a pair of "ear muffs." (Fig. 3B.) The graft is now seen to be substantially entrenched across the curetted bone extending from healthy bone below to healthy bone above. The redundant triceps is plicated upon itself. (Fig. 3B.)

Both of the cases reported also exhibited involvement of the radiohumeral joint with sinuses leading from it. In each case it was decided at the time not to enter this joint surgically. This point is particularly emphasized since it was found, much to our surprise, that the sinuses closed spontaneously, and to all intents and purposes, the radiohumeral joint in both cases had progressed to a clinical cure concomitant with the degree of ankylosis obtained in the elbow joint proper. It would, therefore, appear that other surgery of the radiohumeral joint might not be necessary if complete ankylosis is obtained in the ulnohumeral joint.

#### CASE REPORTS

CASE I. Mr. J. V., age forty-nine, was admitted to the medical service at Grasslands



FIG. 5. Case 1. X-ray shows complete bony ankylosis.

The diagnosis of tuberculosis had been established and since that time had been treated with immobilization in plaster dressings. Repeated x-rays showed a progressive destruction of the elbow joint and of the radiohumeral joint. Sinuses began to appear about the elbow and had persisted up to the time of operation. The largest draining sinuses appeared opposite the radial head. On November 14, 1938, an arthrodesing operation was carried out using the technic described above. A note on August 11, 1940, stated that, "The elbow is clinically fused." He does a good day's work as a farmhand and he suffers no pain whatever. All the sinuses are closed. Pronation and supination in the forearm is about 40 per cent normal.

CASE II. Mr. V. DiL., age twenty, was originally admitted to the pediatric service at Grasslands Hospital for treatment of tuberculous polyserositis involving the pleural cavities, peritoneal cavities and apices of both lungs. From the records it appears that he was finally discharged as cured after a prolonged period of treatment. He first began to complain of the right elbow in 1937. The diagnosis of tuberculosis was made and he was treated with plaster casts. Sinuses about the elbow appeared and closed at different intervals. X-rays showed destruction of all joints at the elbow. Operation was carried out on November 10, 1938. A note on July 22, 1940, stated, "All sinuses are closed

about the elbow which appears clinically solid. Fifty per cent pronation and supination of the forearm remain."

himself, after hopes of locating him were given up. The following is a brief summary of his history as taken in 1940:



FIG. 6. Case 11. Preoperative x-ray. Note loss of radial head.

The pathological specimens in the above cases were found to exhibit, "tuberculous bone and bone marrow."



FIG. 7. Case 11. X-ray shows complete bony ankylosis.



FIG. 8. A, anteroposterior view shows solid fusion of graft from ulna below to humerus above, B, lateral view shows the characteristic "tongue-like" projection formed by the graft where it is closely apposed to the humerus and ulna.

Some time after the above paper was completed, the following patient presented

CASE III. J. DiP., aged thirty-seven, had tuberculosis of the kidney about seven years

ago for which a nephrectomy had been performed. Shortly afterward tuberculous orchitis developed, and this was also treated surgically. Symptoms referable to the elbow started about four years ago. For the past two years sinuses have been draining about the elbow, and he has had splintage for the same period of time. In 1940, the range of painless motion was markedly restricted, and rotation of the forearm was reduced to about 30 per cent of normal. Using the technic described above, operation was carried out in February, 1941. Splintage was removed in April, 1942. He has a well ankylosed elbow with about the same amount of pronation-supination as described above. Only the postoperative x-rays taken recently are available, but these show the same characteristic "tongue" of bone, well coapted to the humerus and the ulna. (Fig. 8A and B.)

#### SUMMARY

1. An improvement in technic is presented for arthrodesis of the tuberculous elbow in the adult.

2. In the face of notoriously poor statistical results, this operation has been completely successful in the three cases described. Although three cases do not constitute a series, I have reason to believe that similar good results will be obtained in future cases.

3. It appears that there may be no need to attack the radiohumeral joint at the time

of the operation. The sinuses may disappear spontaneously, as they did in both the above cases, if the ulnohumeral joint becomes fused.

4. It is of interest to note that the patients desired an attitude of slight extension in the elbow, as the best functional position most suitable to them in their occupations.

5. In view of the excellent results obtained by following the described technic, the writer wishes to recommend this operation to others.

The author wishes to thank Dr. J. C. McCauley, Jr., for permission to use the last mentioned case in this paper.

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# MYXOMA OF THE APPENDIX\*

## CASE REPORT

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**M**YXOMA of the peritoneum is a rare tumor composed of mucoid tissue. It may arise as a primary tumor



FIG. 1. Macroscopic appearance of myxoma in appendiceal mesentery.

probably originating from embryonal mucoid tissue. This is found in the umbilical cord but does not appear normally in other parts of the body. The tumor is seen in connective tissue which has undergone myxomatous metaplasia, a transformation which is considered to be a true metaplasia rather than a degeneration. Ewing refers to a pure myxoma in the mesentery observed by Borst. Woodruff and McDonald, in a study of 146 cases of benign and malignant tumors of the appendix, occurring in a series of approximately 43,000 appendectomies, observed no myxomas. A primary myxoma of the appendiceal mesentery is very rare, and the following case may be considered unusual:

## CASE REPORT

A. H. N., a thirty-four year old white man, began to have abdominal pain approximately fifteen and one-half hours before admission to the hospital. The pain at its onset was aching in character, periumbilical in location; later it became intermittent, cramp-like, and colicky, and ten hours after onset localized in the right lower abdominal quadrant. The pain was associated with active nausea. There had been one similar, but less severe, attack approximately one year previously; otherwise his past history did not contribute any significant illnesses.

Physical examination revealed a well developed, well nourished, white adult male, not appearing acutely ill. The head, neck, heart and lungs were normal. The respiratory rate was 20, pulse rate 100, temperature by mouth 99.0°F., and blood pressure 124 systolic and 90 diastolic. The abdomen moved freely on respiration and there were no tympanites or excessive muscular rigidity. There was tenderness in the right lower quadrant on deep palpation. A small, firm, tender mass was palpable in the ileocecal region. Murphy's sign and the psoas test were positive.

The voided specimen of urine was straw colored, neutral in reaction, and tests for albumin, sugar and acetone were negative. Occasional erythrocytes, leucocytes and epithelial cells were observed microscopically. The blood Wassermann and Meinicke precipitation tests were negative. Blood urea nitrogen determination was 12.5 mg. per 100 cc. The total erythrocyte count was 4,800,000; hemoglobin (Sahli) 96 per cent; sedimentation time—first hour 15, second hour 40, method of Westergren; total leucocytic count 15,300; differential leucocytic count—68 per cent segmented

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polymorphonuclear leucocytes, 1 per cent eosinophiles, 6 per cent monocytes, 27 per cent lymphocytes. Mild toxic granulation was

tip. On sectioning the lumen was found to be patent throughout and the mucosa smooth. There was fecal material and a small amount

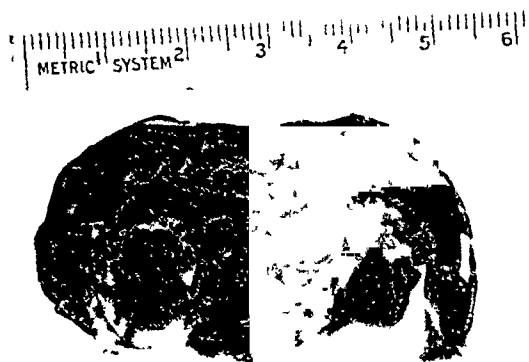


FIG. 2. Longitudinal section of appendix showing subperitoneal location of myxoma in subserosa.

observed in 36 per cent of the segmented granulocytes.

With a preoperative diagnosis of acute appendicular obstruction, the abdomen was opened through a Krammerer-Jaboulay incision, four hours after admission and nineteen and one-half hours after onset of the illness. The omentum had a granular appearance. The appendix was found low. At the tip of the appendix there was a bluish mass with a diameter about one-third larger than that of an olive. In delivering the appendix the mass was ruptured. The rupture was pin-point in size and there exuded from the mass material having the general appearance of white caviar. The base of the appendix was ligated low, and the structure plus the mesentery, was excised. The stump was buried and the wound closed in the usual manner.

The wound healed per primum, and after an uncomplicated and uneventful recovery the patient was discharged from the hospital as cured on the eleventh postoperative day. He returned to his work as a salesman and to the date of this report, three years later, has been free from symptoms or physical findings of recurrence of the newgrowth.

**Surgical Pathological Protocol.** The specimen was a whitish-gray, vermiform appendix, measuring 6 cm. in length and 1.5 cm. in diameter. There was a reddish-gray bulbous area at the tip, measuring 2 by 5 cm., and covered with a thin layer of fibrin. Purulent exudate exuded from a small opening in the

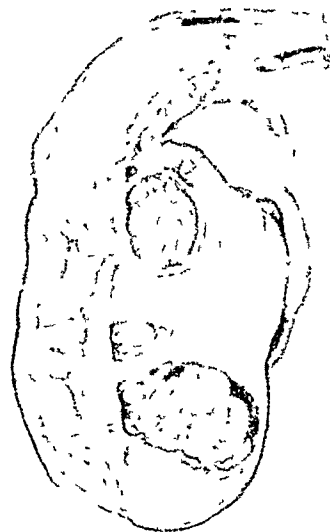


FIG. 3. Internal view of appendix. Note glistening, gelatinous appearance of myxomatous tissue.

of exudate in the lumen. There were several encapsulated areas, 5 to 12 mm. in diameter, in the subserosal layer, which contained a gelatinous appearing substance. (Figs. 1, 2 and 3.)

**Microscopic:** The lining epithelium was moderately hypertrophied. The tubular glands were short, and lined with columnar epithelium with occasional mucous droplets in the cytoplasm. The lumen contained a small amount of exudate made up largely of lymphocytes and polymorphonuclear leucocytes. The lymphoid follicles were atrophied. The tunica propria was infiltrated with numerous plasma cells and a moderate number of eosinophiles. The submucosa was increased in thickness and made up largely of fat cells and fibrous connective tissue containing scattered polymorphonuclears and lymphocytes. The subserosal layer was edematous, of increased thickness, contained perivascular infiltration of lymphocytes, and was diffusely infiltrated with polymorphonuclears, lymphocytes and plasma cells. This layer also contained areas, 5 to 12 mm. in diameter, made up of a delicate reticulum of connective tissue cells, between which there was abundant precipitated grayish basophilic mucoid material. The cells were stellate and spindle-shaped with spindle nuclei predom-

inating. The cytoplasmic processes of the cells were lost in the mucinous intercellular substance. Scattered throughout the tumor, and

removal at the first operation. The neoplasm is not completely encapsulated and has a marked tendency to recur locally,



FIG. 4. Section through wall of vermiform appendix. Note atrophy of lymphoid follicles, fibrous connective tissue in thickened mucosa, and area of extravasated erythrocytes in tunica muscularis (U. S. Army Medical Museum. Neg. No. 67969. Photomicrograph  $\times 32$ .)

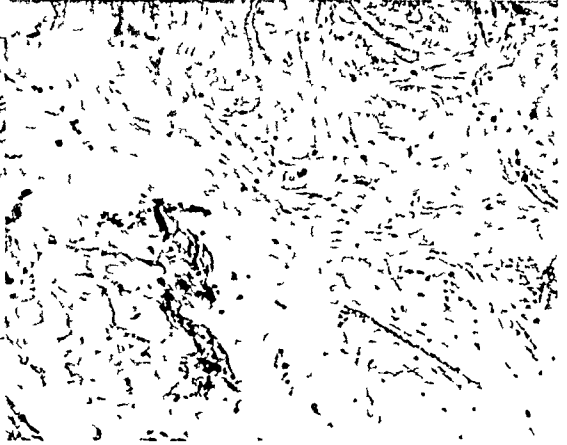


FIG. 5. Section through myxomatous connective tissue in subserosal layer of the vermiform appendix. Observe spindle and stellate cells in matrix of mucinous substance. (U. S. Army Medical Museum Neg. No. 67968 Photomicrograph  $\times 320$ .)

adjacent to it, there were numerous mononuclear cells, eosinophiles and polymorphonuclears. There was a small area of extravasation of erythrocytes in the tunica muscularis. (Figs. 4 and 5.)

The material was also studied by J. E. Ash, Lieutenant-Colonel, Medical Corps, Curator, U. S. Army Medical Museum, Washington, D. C., who reported that the enlargement was due to a myxomatous type of connective tissue with involvement of the serosa, together with chronic inflammatory exudate scattered through the tumor portion. The specimen has been mounted at the Army Medical Museum, accession No. 59,985.

*Histopathological Diagnoses:* Myxoma—appendiceal mesentery. Appendicitis—recurrent acute.

#### TREATMENT

The treatment of myxoma is wide surgical excision. In this case the appendix was removed with the appendiceal mesentery containing areas of myxomatous connective tissue. The myxoma cells infiltrate the tissue widely about the primary tumor. The extent of infiltration cannot be accurately gauged from macroscopic inspection, hence a wide margin of tissue must be excised with the tumor to obtain a complete

principally because of inadequate removal, either from excision with a too narrow margin, or because of anatomical difficulty of complete removal. In the event of recurrence, the treatment indicated is further adequate surgical excision. It is imperative that the mucoid material be removed without soiling the wound, as spilling of the material results in widespread distribution of the neoplasm throughout the peritoneal cavity. Intestinal obstruction may occur many years later as a complication from peritoneal implants of myxomatous tissue.

#### DISCUSSION

The mucoid tissue found in a myxoma normally occurs in the umbilical cord but not in other parts of the body. A pure myxoma is readily recognized macroscopically by its slimy character and soft, moist, translucent, gelatinous appearance. It occurs in subcutaneous, subserous and intermuscular tissue. Myxomatous connective tissue in the appendix must be differentiated from mucocoele of the appendix. In the latter pathologic entity the dilated appendix is filled with mucinous material. As a result of inflammation, the proximal

part of the appendix becomes completely closed and mucin accumulates and dilates the distal portion. The differentiation is made by the appearance of the lumen and the character of its content, by careful microscopic sections of material throughout different areas of the wall, and cytological study of the exudate from the lumen. Tumors of benign histologic structure often recur with areas of sarcomatous structure, hence the prognosis in myxoma should always be guarded. Such tumors are termed myxosarcoma.

#### CONCLUSIONS

1. A case of myxoma of the appendiceal mesentery is presented with a three-year cure after surgical treatment.

2. The treatment of myxoma of the vermiform appendix is complete surgical excision.

3. The prognosis in such tumors must be guarded because of the frequency of local recurrence, the danger of peritoneal implants of myxomatous tissue with late complication, such as intestinal obstruction and the recurrence of myxosarcoma in the case of myxomatous tumors of benign histologic structure.

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# CALCIFICATION OF OVARIES

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CALCIFICATION of ovaries is a comparatively rare condition. Up to 1930 there had been only about nine reported cases and most of these repre-

ing in definite circumscribed areas where true bone formation is seen with haversian canals penetrating the calcification. These are termed corpus albicans.



FIG. 1. A flat abdominal plate showing two distinctly calcified, opaque masses situated laterally in the pelvis.



FIG. 2. Lipiodol injection of the uterus showed these masses to be extra-uterine. The uterine cavity is fairly normal in size and contour.

sented calcification of a single ovary. The calcification of both ovaries is an extremely rare condition.

## TYPES

Calcification is especially seen in ovarian tumors, fibroids and dermoids. There is another type of calcification seen in an ovary and about the tubes. These are the concrete, isolated, discrete, laminated calcium nodules called psammoma bodies. This term was coined by Virchow in 1863 when he was writing of the presence of these bodies about the covering of the brain.

Dr. Wm. Wilson, in the *Western Journal of Surgery* in 1933, wrote extensively, citing numerous cases of psammoma bodies in ovaries and tubes.

There is another type of calcification seen in the ovary that is the calcification that occurs in healed corpus luteum cysts result-

The metaphysics of the calcification are both mechanical and chemical. Naturally, there is no fixed demarcation between the mechanical and chemical causes. Each produces calcification as they favor one another in a rather vicious cycle.

Dr. Eli Moschcowitz writing in 1916 in the *Bulletin of Johns Hopkins Hospital* states that the process of calcification is analogous to the normal physiological endochondral ossification, the only difference being the ossification occurring in ovaries which follows the formation of hyaline connective tissue. Dr. Moschcowitz also stated that calcification occurs only in dead tissue.

Dr. Whitridge Williams writing in the *Trans-American Gynecological Society* in 1893 believes that there occurs in the ovary a coagulative necrosis with diminishing blood supply. He also states that there are varying and intermittent amounts of

lymph and blood to the tissues promoting the formation of hyaline tissue and precipitation of lime.

Dr. Wagner believes calcium is precipitated by the stagnation of interstitial fluids.

Dr. J. M. Gamble, writing in *Chemistry and Medicine* in 1928, states and has proved to his own satisfaction from a chemical standpoint, that calcium phosphate in the blood serum is precipitated by any lowering in the carbon dioxide content of the tissue fluids. Chronic inflammation with stagnation, slowing of the blood supply and the production of local acidosis make a condition favorable for the lowering of carbon dioxide.

Dr. Hellmut Kamniker writing in 1921 states emphatically that bone formation in cartilage occurs in the ovary only in teratomas. He attempts to explain the formation of calcium by the metaplasia of the already existing cells into other cells capable of forming calcium and bone. He states that puerperal sepsis with thrombosis is likely the predisposing cause of calcified ovaries.

#### SYMPTOMS

The symptoms of calcification of ovaries are those that you naturally expect: (1) There is a sense of weight and fullness in the pelvis; (2) severe aberration or cessation of the menstrual cycle depending upon the amount of normal residual ovarian tissue not involved in the calcification process; and (3) the history of some pre-existing pelvic infection which would tend to explain the local stagnation, hyaline degeneration and acidosis.

#### DIAGNOSIS

Diagnosis is confirmed by the presence of very hard unyielding parametrial body or bodies upon vaginal examination. Diagnosis is made certain by the x-ray examination with the finding of dense opaque bodies lateral to the uterus.\*

\* Further case reports on the subject have been reported by H. A. Curtis, Ivens, Margaret Salmon, T. C. Bost, and A. L. McIlroy.

#### CASE REPORT

This is a case of Mrs. W. H. B. age 38, white, who came in to see me stating that she believed



FIG. 3. Specimens consisting of both ovaries which were diseased. Both contained deposits which were stony hard in character.

that she was about eight months pregnant on account of her enlarged abdomen and almost complete cessation of menstruation for many months.

She stated that her last normal period had been nine months before and that before this her periods as she recalled, were fairly regular. Since her last normal period she had seen spotting at intervals, maybe a day or day and a half at a time, but that she had seen no normal menstruation for the last nine months.

Examination revealed a rather obese woman with the contour of the abdomen just fat and not suggesting the presence of pregnancy. There were no demonstrative breast changes and no fluid in the nipples. She was not nauseated. Palpation of her abdomen did not reveal any mass but a considerable amount of extra fascial fat. Auscultation of the abdomen revealed only what was interpreted as normal peristaltic sounds.

Vaginal examination revealed a very small cervix hard in consistency, no lacerations and only an inconsequential amount of erosion. This patient, as already stated, was very obese and on vaginal examination very hard unyielding masses could be found behind and lateral to the uterus.

A flat abdominal plate was made which showed two distinctly calcified, opaque masses situated laterally in the pelvis. (Fig. 1.) Lipiodol injection of the uterus was done and a second x-ray was made which showed these masses to be extra-uterine. The uterine cavity was fairly normal in size and contour. (Fig. 2.)

An operation was advised for the patient and was accepted. Preoperative diagnosis was made of calcified masses of the adnexa most probably of the ovaries and likely calcified dermoids.

At operation a uterus normal in size and shape was found, also normal tubes and a large calcified ovary on either side. The shape of these ovaries vaguely resembled the shape of a normal ovary but they had the consistency of billiard balls.

The postoperative convalescence was fairly uninterrupted and after about ten days, at which time she was in good condition, a gallbladder function test was done and was reported normal with no stones in the gallbladder. There were no stones in the urinary tract. A blood calcium was done on this patient which was 8 mm. per 100 cc. of blood. There was evidently no constitutional disturbance of calcium metabolism as 8 mm. is a low normal and she had no unusual calcification in any other portion of her body. It appears that this calcification was a localized circumscribed process in the ovary itself.

*Pathological Report. Gross Appearance:* The specimen (Fig. 3) consisted of both ovaries which were diseased. They both contained deposits which were stony hard in character. In some positions these deposits were yellowish and transparent, and looked very much like cholesterol. In other portions they were opaque and seemed to be composed of calcium. One

ovary weighed 87 Gm. and one 96 Gm. The over-all dimensions of one ovary were  $7\frac{1}{2}$  by 4 by 3 cm. The Fallopian tubes were intimately attached to the masses and there was a small amount of soft ovarian tissue on one of the masses. However, for the most part the ovarian tissue had been entirely replaced by this stony hard material.

*Microscopic Appearance:* On section of the soft portion of one of the ovarian masses, rather normal ovarian tissue was seen. There were numerous primordial follicles. There was a well developed corpus luteum and numerous corpora albicans. There was some blood pigment scattered near the corpus luteum. The areas of calcification were bordered by fibrous tissue. The fibrous tissue around the large mass contained small specks of calcium also. There was no clue in the sections as to just what part of the ovary this calcification may have had its inception, but the end result was encapsulation by dense fibrous tissue.

*Pathological Diagnosis:* Bilateral calcification of ovaries.

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# HEMANGIOMA OF THE STOMACH

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THIS report includes the record of one case of hemangioma of the stomach and a review of the literature concerning this condition. This case is of interest because there were no symptoms, and the tumor was accidentally found during an exploratory operation for a stab wound of the abdomen. The mass was excised and sent to the pathology laboratory for diagnosis.

## CASE REPORT

C. C., aged forty, a common laborer, was admitted to the surgical service of Provident Hospital on April 22, 1941, with a history of a stab wound of his abdomen. The injury was acquired following an altercation about ten blocks from the hospital.

Immediately after examination in the accident room, the patient was placed in bed in antishock position and given treatment for shock. In less than an hour he was operated upon.

The history of patient prior to this accident was not remarkable. Not infrequently, he had suffered from pains in the epigastric area and headaches following overindulgence in alcoholic beverages. These attacks usually cleared up within twenty-four hours. There was no history of constipation, black stools or even a little blood in his stool and no history of weight loss at any time. His eyes were good, hearing was normal, appetite was good and his nose, throat, and chest except for infrequent attacks of coryza in the fall and winter seasons had caused no serious trouble. He gave a history of a gonococcal infection at age of seventeen years and again at the age of thirty-four years. In both instances, symptoms were eliminated following medical treatment.

Physical examination revealed a fairly well developed and well nourished adult negro patient. Head, neck and chest were essentially negative. The abdomen was normal in size and shape. A penetrating stab wound, with omentum protruding from same, was noted

about 2 cm. to left of midline midway between xiphoid process and umbilicus. The laceration of skin was about one inch in length and horizontal in direction. Palpation about the wound showed some tenderness in both lumbar regions. No physical sign of fluid in his abdomen was noted. His skin was dark brown, smooth, moist, and showed a number of healed scars over the extremities. No nevi or otherwise unusual lesions were noted.

Blood count showed 4,200,000 red cells and 11,850 white cells per cmm. with 88 per cent hemoglobin. The Wassermann reaction of the blood was positive. Except for traces of albumin and sugar urinalysis was essentially negative. (Test made after infusion of glucose and normal saline.)

At operation a lengthy midline incision was made for exploration of abdominal contents. A laceration of the omentum near the greater curvature of stomach close to pylorus, and two small lacerations of jejunum were repaired. A protruding, palpable, prominent bluish-red mass about the size of a small marble, and covered by an apparently normal serosa, was noted on anterior surface of the stomach. This mass was near the greater curvature in the pyloric portion of the stomach. The tumor mass was excised and the operative wounds were closed in the accepted manner. No diagnosis of the type of tumor was attempted prior to time the specimen reached the pathological laboratory. Lymph glands were normal and no pathological changes were noted in any of the abdominal viscera examined during the operation. The patient had an uneventful convalescence and left the hospital on May 1st. He was last seen twenty-five days after the operation, at which time he was in the best of health and offered no complaints.

*Pathological Report.* The specimen consisted of a small mass removed in an elliptical manner, about the size of a small marble and covered by two well defined layers of tissue. A light bluish-red color was noted over both surfaces about the firm, spherical and somewhat movable inner mass. Section revealed

definite outer layers surrounding a circumscribed bluish-red, gelatinous-like rounded mass of tissue with a diameter of 1 cm. A



FIG. 1. Photomicrograph showing section of the hemangioma in the muscular wall of the stomach. The mucosa of the stomach is at the top and is distinct. The cavernous spaces in the tumor mass are outstanding and the tumor can be seen to invade the subserosa below.  $\times 8$ .

sanguineous fluid exuded from the cut surface.

*Microscopic Examination.* The mucous membrane of the stomach was normal throughout. The growth was in the muscular wall and extended through to the submucosa. It was characterized by capillary walls lined by endothelium. The area was supported by proliferating endothelium in which there were many lymphocytes and large monocytes most of which contained blood pigment. There were a few polymorphonuclears and proliferating fibroblasts present.

*Diagnosis:* Cavernous hemangioma in the muscular layers of the stomach wall.

#### COMMENT

A hemangioma is a tumor produced by a new formation of blood vessels. It is quite common in some locations and is usually called an angioma. Two types are usually seen: the capillary and the cavernous. Cavernous hemangiomas are less common, having the same structure as erectile tissue, and are composed of large blood spaces or sinusoids lined by endothelium. It is extremely rare to find a tumor showing a complete cavernous change. In almost all reported cases if the cavernous hemangioma is present, it is associated with the

capillary type with varying changes in transition between the two.

In reviewing the literature, it is obvious



FIG. 2. Photomicrograph of the hemangioma showing more in detail the cavernous spaces.  $\times 100$ .

that benign tumors of the stomach are infrequent, and that vascular tumors are especially rare in this group. Lemon, in 1920, reported one case of angioma of the stomach to add to the five of which he had knowledge, namely, the cases reported by Guisez, Stockis, Burty, Lammers, and one by Sherril and Graves. Kornmann, in 1913, stated that hemangioma constituted only 7 per cent of all benign tumors of the entire gastrointestinal tract.

Balfour and Henderson, in 1927, published a report on a study of fifty-eight cases of benign tumors of the stomach that had come up for operation at the Mayo Clinic up to the time the article was written. In this series there were only four cases of hemangioma of the stomach. Three of the four patients with hemangioma had suffered from slight dyspepsia and a fourth from recurring attacks of diarrhea. The outstanding features of this group, however, were the previous occurrence of melena in three cases and of severe hematemesis in one. In only one case was gastric acidity abnormal; there was no free hydrochloric acid. The hemoglobin in two of the cases was 44 and 47 per cent, respectively. The tumors varied from 2.5 to 6 cm. in diameter, and the largest weighed 108 Gm. They were all single and pedunculated. Two were ulcerated and none had undergone malignant degeneration.

McClure and Ellis, in 1930, published the records of twenty-five patients who had been found to have hemangioma of the gastrointestinal tract. Of these, fourteen were single and eleven multiple. There were no cases of hemangioma of the stomach in this group. The records of two additional patients and a complete review of the literature were published by Kaijser in 1936. He classified seventy-four verified

of benign tumors of the stomach and presented the clinical and pathological features of fifty benign tumors of the stomach recorded in the Johns Hopkins Hospital from 1889 to September 1936. According to the tissue of origin they divided the tumors into two groups: epithelial and mesenchymal. Among the epithelial tumors were adenomas, adenopapillomas, adenomyomas and fibroade-

TABLE I  
CLASSIFICATION BY KAIJSER OF VERIFIED INSTANCES OF HEMANGIOMA OF GASTROINTESTINAL TRACT

Classification (Kaijser)	Pinpoint Multiple Varicosities	Diffuse Infiltrating Cavernous Hemangioma	Circum- scribed Cavernous Polypoid Hemangioma	Hemangioma Simplex (Telangi- ectasis)	Hemangio- matosis
Group	I	II	III	IV	V
Sex	24M 3F	14M 8F	5M 5F	5M 2F	2M 5F; 1?
Age variation	26-79	3 mo.-48 yr.	15-62	3 mo.-64 yr.	2 mo.-61 yr.
Location					
Esophagus	2	1			
Stomach	2			2	2
Duodenum				2	
Jejunum	9			1	
Ileum	7			1	
Meckel's diverticulum			1		
Small intestine		7	4	1	3
Cecum				1	1
Sigmoid flexure		7	1		
Rectum	3	12	3		
Large intestine	9			..	2
Gastrointestinal tract			1	.	6
Total cases	27	22	10	7	8

instances of hemangioma of the gastrointestinal tract into five groups, which may be summarized as in the accompanying Table I. (From Pierose's report of hemangioma of the gastrointestinal tract.)

Ewing refers to Kaijser's "hemangioma simplex" group as being synonymous with "telangiectasis." Kaijser also included a fifth group in his classification, "hemangiomatosis." Cases under this classification presented hemangiomas in other organs in addition to those found in the gastrointestinal tract.

Minnes and Geschickter, in 1936, published an article reviewing the literature

noma. Chief among the mesenchymal tumors were the leiomyomas, fibromas, lipomas, neurofibromas and the rare angiomas and osteomas. According to their report hemangiomas are rare. Ten had been collected by Eliason and Wright, to which five more recent cases were added. In the series of fifty cases reported by Minnes and Geschickter, there was only one case of hemangioma. In regard to the mesenchymal tumors, the latter authors state that they may be sessile or pedunculated. They lie within the wall of the stomach, project into its lumen or remain subserous and project into the peritoneal cavity. They are usually

small but sometimes grow to tremendous size. Occasionally, by virtue of their size and position, they cause embarrassment of the circulation to the supra-adjacent mucosa, resulting in necrosis and ulceration. Rarely do they undergo hyaline, cystic or malignant change.

wound of the abdomen. During the operation a small bluish area projecting from the serosal surface of the stomach was excised. A pathological diagnosis of cavernous hemangioma of stomach was made. There was no history of any symptoms in relation to the tumor.

TABLE II  
INCIDENCE OF BENIGN TUMORS OF THE STOMACH  
GATHERED FROM THE LITERATURE BY MINNES  
AND GESCHICKTER

	No.	Per Cent
Epithelial		
Polyps.....	182	19.5
Papillomas.....	89	9.5
Adenomas.....	42	4.5
Polyposis.....	16	1.7
Mesenchymal		
Leiomyomas.....	341	36.6
Neurofibromas.....	102	10.9
Fibromas.....	42	4.5
Lipomas.....	32	3.4
Osteomas.....	1	0.1
Osteochondromas.....	1	0.1
Myomas.....	3	0.3
Endothelial		
Hemangiomas.....	15	1.6
Lymphadenomas.....	14	1.5
Endotheliomas.....	12	1.2
Cysts		
Simple.....	29	3.2
Dermoid.....	5	0.5
Echinococcic.....	4	0.4
Total.....	931	

#### SUMMARY AND CONCLUSION

A patient came to accident room of hospital with the complaint of a stab

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# LEIOMYOMA OF THE SPERMATIC CORD

## CASE REPORT

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**L**EIOMYOMA appears to be one of the rarest of a small group of neoplasms arising from the structures of the

been aspirated and a large quantity of thin, watery fluid removed.

Examination revealed a mass in the right

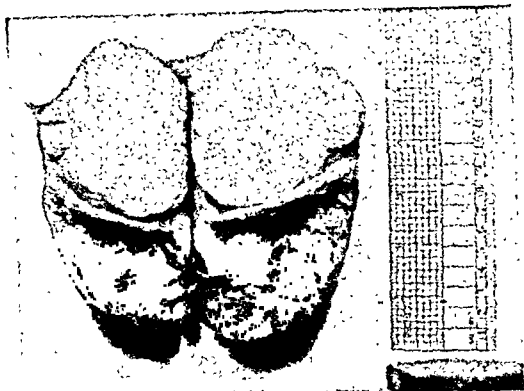


FIG. 1. Gross appearance of sectioned tumor. The tumor appears at the top, the testicle at the bottom and the hydrocoele between.

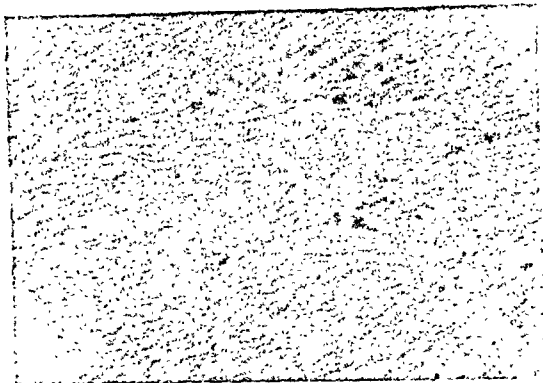


FIG. 2. Photomicrograph showing intertwining bundles of smooth muscle.

spermatic cord. Schulte, McDonald and Priestly,<sup>1</sup> in 1939, reviewed all reported cases of tumors of the spermatic cord and found only three leiomyomas out of a total of 247 tumors. They also list two cases of leiomyosarcoma one of which was reported by Thompson<sup>2</sup> in 1936. This tumor appeared histologically to be myoma but, because of repeated recurrences, was classed as leiomyosarcoma.

The following case report is of interest due to its rarity, its comparatively large size, and its coincident association with a hydrocoele which led to an erroneous pre-operative diagnosis:

### CASE REPORT

A sixty-six year old colored male was admitted to the urological service on August 19, 1938, with the chief complaint of a swelling of the right side of the scrotum. There had been a gradual increase in size of a painless mass in the right side of his scrotum for a period of one year. One week before admission the mass had

side of his scrotum measuring 11 by 15 cm. The mass was slightly tender and the skin over it was edematous, thickened and indurated. It did not transmit light and was irreducible. A diagnosis of hydrocoele was made and 120 cc. of straw colored fluid aspirated. A right orchidectomy was performed five days later with ligation of the spermatic cord at the internal ring. Convalescence was uneventful and the patient was discharged on the twelfth postoperative day.

*Pathology.* The specimen was an elongated mass measuring 18 cm. in length and 10 cm. at its greatest width. Its external surface showed fibrous strands which represented adhesions separated at operation. On section three sharply separated masses were found which presented widely different gross features. At one extremity a testicle measuring 4.5 cm. presented no unusual characteristics except edema. The seminiferous tubules could be easily extracted. At the upper extremity of the testicle occupying the position of the epididymis there was a pinkish, edematous, fleshy mass measuring 2.5 cm. At the opposite extremity of the mass was an ovoid, solid circumscribed tumor measuring 10 cm. in diameter. On section its

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pinkish-white surfaces bulged and presented a series of nodules measuring from 1 to 4 cm. in diameter. These latter were separated by broad zones of wet semitranslucent tissue in which one detected evidence of intertwining. A middle triangular, cystic structure measuring 8 cm. in its greatest width was filled with greenish fibrin that was saturated with fluid of a similar color. This appeared to be enclosed by the thickened tunic and its lining was red and granular.

Microscopically, the tumor was composed of typical smooth muscle cells arranged in whorls with interlacing bands between of similar tissue. There were diffusely scattered nodules of almost pure smooth muscle tissue. The connective tissue scattered between the muscle cells was not a predominant feature. The tumor had an appearance identical with that of a leiomyoma of the uterus. The testicle showed only edema. The epithelial lining of the hydrocoele was absent, being replaced by granulation tissue covered with fibrin.

#### SUMMARY

A case of leiomyoma of the spermatic cord is reported occurring in a sixty-six year-old colored male. The only symptoms were a painless mass that gradually increased in size over a period of one year. The association of a hydrocoele, proved by aspiration, led to an erroneous diagnosis. The tumor was 10 cm. in diameter and had the appearance of a uterine leiomyoma. This is believed to be the largest such tumor reported and is the fourth one found in the literature.

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# PRIMARY NEUROGENIC SARCOMA OF THE FOREARM FOLLOWING TRAUMA AT GOLF

## CASE REPORT

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**I**SOLATED solitary neurogenic sarcoma of peripheral nerves unassociated with von Recklinghausen's disease is uncommon. Its occurrence is even more unusual following a definite history of trauma.

The accessibility of these tumors generally leads one to minimize their serious nature and most often to mistake them for benign growths. It is rarely diagnosed as malignant until pathological examination has been made and in many cases, the tumor small or large is removed without considering the necessity for radical extirpation at the time.

It is difficult to determine whether these isolated growths arise from the neurilemma, perineurium or epineurium, but the connective tissue nature of these growths make it probable that they originate from either of these structures.<sup>1</sup>

Stout<sup>2</sup> maintains that there are two classes of malignant tumors that develop in peripheral nerves; those of mesoblastic origin and those derived from neuro-epithelium.

Penfield<sup>3</sup> and Mallory<sup>4</sup> believe that these tumors arise from the supporting endoneurial connective tissue and are, therefore, of mesodermal origin.

Masson<sup>5</sup> and Verocay<sup>6</sup> are of the opinion that the majority of these neoplasms originate from the Schwann cells of nerve sheaths, which have their anlage from the neural crest, hence are of ectodermal origin.

Neurofibrosarcoma usually develops in superficial and deep nerve trunks. The tumors are composed of varying numbers and sizes of cells, the more cellular forms being the more malignant.

Quick and Cutler<sup>7</sup> have graded these tumors into three different varieties, designating Grade I, II and III, depending on



FIG. 1. Volar-lateral aspect of left forearm showing area excised and covered by a Wolf skin graft.

their cellular content. The more acellular group I, being the more benign type and grade III, being the most malignant.

Fischer,<sup>8</sup> in 1927, reviewed the literature on von Recklinghausen's disease, and of the 466 cases reported up to that time found that 13 per cent were complicated by sarcomatous degeneration in the nerve tumors.

Garre<sup>9</sup> studied the differences between primary sarcomas of nerves and secondary sarcomas complicating pre-existing von

neurosarcoma of the median nerve of the arm due to definite trauma two years before.



FIG. 2. Illustration showing a spindle cell sarcoma with considerable mucoid degeneration between the cells. Mitotic figures are not abundant. The arrangement of the cells very strongly suggests a neurogenic sarcoma and several nerve bundles, present in the substance of the tumor, are suggestive of the site of origin for the neoplasm.

Recklinghausen's disease and found the latter more prone to remain encapsulated for longer periods of time. He reported the former to be of greater malignancy and metastasize earlier to internal organs.

Quick and Cutler,<sup>7</sup> reported that fourteen patients out of seventy two with neurogenic sarcoma unassociated with von Recklinghausen's disease, gave a history of trauma, but stress that they believe that chronic irritation or repeated traumatic insults are more important if trauma as an etiology can be considered.

Stewart and Copeland,<sup>10</sup> on the other hand, record eight instances of trauma among their eighty-three cases, but they believe "in no case is the analysis sufficient to make the traumatic etiology secure beyond doubt."

Cramer,<sup>11</sup> in 1929, showed that chronic irritation by tar painting produced this form of tumor which recurred after excision.

Biggs<sup>12</sup> reported the occurrence of a

Most authors insist that radical one-stage wide excision or amputation should be performed and unless complete extirpation is done early, there is great danger of recurrence and metastasis. Many authors on this subject point to the relative rarity of the neurogenic sarcomas and their benign appearance and that the general surgeon does not encounter them frequently enough to be familiar with their highly malignant nature.

Quick and Cutler<sup>7</sup> out of twenty-four cases had a mortality (exclusive of tumors of the thigh) of 50 per cent from metastases. Of the cases of tumors of the thigh the result was still worse; only two out of fifteen are still living from three to nine years after operation. Twenty per cent of all their patients with neurogenic sarcoma died from pulmonary metastases.

The case of solitary neurogenic sarcoma of the forearm which I wish to report is unique and significant. It followed a

definite trauma to the left forearm while the patient was playing golf.

#### CASE REPORT

M. B., twenty-five years of age, American, complained of pain and swelling on the volar aspect of the left forearm, since striking it with the end of a golf club while driving a golf ball five weeks before. He experienced pains in the flexor aspect of the left forearm which radiated up to the arm and down to the fingers. At first he paid little attention to the injury. He did notice, however, the development of a small nodule on the volar aspect of the forearm. It was painful and tender.

Upon examination, I found at the volar surface of the left forearm four inches proximal to the wrist joint, a firm, tender, subcutaneous tumor, the size of a small hazel nut. It was fixed to the underlying tissues but the skin over it was freely movable. There was no adenopathy of the epitrochlear, axillary, subclavicular or cervical glands.

On October 15, 1938, under local anesthesia, a biopsy of the growth was made. The specimen was submitted for pathological examination to Dr. R. C. Scleussner who reported spindle cell sarcoma. Sections were reviewed by Dr. Francis Carter Wood, Dr. Paul Klemperer and Dr. H. R. Muller who confirmed the pathological findings of spindle cell sarcoma of neurogenic origin.

On November 3, 1938, at Doctors Hospital, I performed a wide excision of the tissues of the volar-lateral region of the forearm, encircling the site of the biopsy. The oval area excised measured  $3\frac{1}{2}$  by 10 inches. It included the skin, superficial fascia and nerves, deep fascia and a portion of the muscular tissue at the site of the tumor. It was excised *en masse*. There were gray strands of neoplastic tissue invading the deep fascia at the site of the tumor.

A Wolf skin graft was removed from the proximal aspect of the left thigh and grafted over the exposed region of the forearm. It was sutured by fine silk interrupted atraumatic sutures. A splint was applied to the posterior aspect of the arm which was flexed at right angles.

The Wolf skin graft healed completely within two weeks with the exception of a few small hemorrhagic blebs which became necrotic.

These areas were later covered with small Thiersch grafts. Complete healing resulted shortly thereafter. The skin over the operated area became pigmented but was elastic and freely movable. There were no adhesions between the original skin graft and the flexor tendons of the forearm. There was full mobility of the fingers and wrist.

Two and a half years after operation, the patient has some periodic neuralgic pains in the left forearm. There remains cutaneous anesthesia over the grafted area, but he has normal use of the limb.

Roentgen ray examination of the bones of the body does not reveal any metastases. There is no adenopathy and the patient is in apparent good health.

#### SUMMARY

1. A unique case of solitary neurogenic sarcoma of the left forearm, following a definite history of trauma at golf, is reported.

2. An early biopsy and radical excision were performed.

3. Two and a half years following operation there is no evidence of metastases.

4. No postoperative radiation was administered because of insensitivity of this neoplasm to radiation.

5. Early recognition and radical extirpation of neurogenic spindle cell sarcoma of a limb seem to obviate the necessity for amputation in these highly malignant lesions.

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# PAPILLARY ADENOCYSTOMA LYMPHOMATOSUM OF THE NECK\*

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ONE of the tumors infrequently encountered in the region of the salivary glands is the papillary



FIG. 1. The tall, columnar cells are shown with nuclei arranged at the same distance from the inner margin. The basal row of cells is seen in some areas and also a lymph follicle with a prominent secondary nodule. Hemalum and eosin.  $\times 160$ .

adenocystoma lymphomatosum, sometimes called an adenolymphoma or onkocytoma. The histologic structure is very characteristic and is easily recognized by the peculiar tall columnar epithelium and the lymphoid stroma. Papillary formations may or may not be present.

Carmichael, Davie and Stewart<sup>1</sup> in 1935, described eight cases and reviewed the literature. They were able to find only two instances which were considered malignant. In 1937, Harris<sup>4</sup> reported two cases making a total of forty-one known tumors. Freshman and Kurland<sup>2</sup> in 1938 found a total of fifty-four cases reported in the literature.

The tumor is usually a slowly growing, painless nodule. The most common location is on the outer aspect of the parotid gland. Several cases have been found behind or below the angle of the jaw and a few in relation to the submaxillary gland. The tumor has been found in much greater predominance in males. The age incidence is chiefly between forty-five and seventy years of age. Two tumors have been found in children, one at two and one-half years of age and the other at twelve years of age.

## CASE REPORT

A white male, forty-eight years of age, had been aware of a slowly growing lump in his neck for one month. It was located in the subcutaneous tissue behind the angle of the jaw on the left side, and at the anterior border of the sternocleidomastoid muscle. The mass was freely movable and was removed without difficulty.

The gross specimen consisted of a soft lobulated cystic mass measuring 15 by 14 by 12 mm. The cut section showed a central cavity containing pale yellow, viscid fluid. There were numerous intracystic papillary formations some of which contained minute cysts.

*Histologic Description.* The tumor consisted of tubular alveoli and irregular cystic spaces with numerous intracystic papillary formations. These structures were lined by epithelium consisting in most places of two layers of cells,

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an inner row of high columnar cells and a basal layer. The inner, tall, columnar cells had round or oval nuclei containing fine chromatin

studies of Hamperl<sup>3</sup> later amplified by Jaffé<sup>5</sup> resulted in the introduction of the term "onkocytoma." Hamperl called at-



FIG. 2. The papillary formations are shown with the tall columnar cells replaced in some areas by narrow, darker staining cells. Phosphotungstic acid hematoxylin stain.  $\times 160$ .

granules and finely granular eosinophilic cytoplasm. The nuclei were situated at approximately the same distance from the free surface. (Fig. 1.) The cytoplasm of some of the columnar cells was reduced in amount and contained large granules which stained deeply with eosin. These cells contained small pyknotic nuclei. Adjacent to these shrunken cells were clear spaces which broke the continuity of the free epithelial surface. Heidenhain's iron hematoxylin and Mallory's phosphotungstic acid stains showed the darker staining cells with much greater contrast than when stained by the ordinary hematoxylin and eosin stain. These cells were interpreted as undergoing degenerative changes. No cilia or blepharoplasten could be seen. The basal row contained fewer cells than the inner tall columnar layer. (Figs. 2 and 3.)

#### COMMENT

The origin of the tumor has been the subject of considerable discussion. The

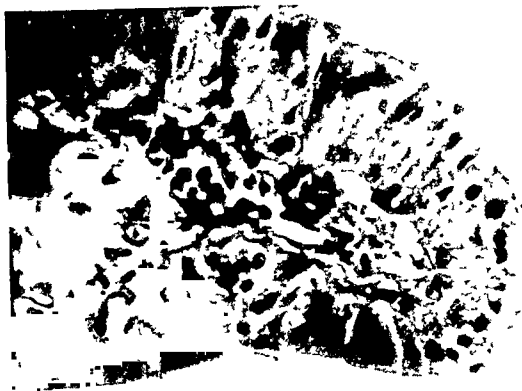


FIG. 3. The tall columnar cells and the incomplete basal layer of cells is shown under high magnification. Phosphotungstic acid hematoxylin stain.  $\times 600$ .

tention to a peculiar type of cell which he found in material from the sublingual and submaxillary glands and also from the uvula and palate. He noted the resemblance between these cells and the epithelium which had been previously described in tumor formations located in the region of the salivary glands. Harris<sup>4</sup> discussed the relationship of the "onkocytes" to the formation of tumor masses with similar epithelial elements and concluded that the origin of the tumor cells has not been proved to be from the onkocytes. He stated that the most acceptable theory of the origin of the tumor is from heterotopic salivary gland epithelium in lymphoid tissue. A branchiogenic origin has been held by several investigators.

#### SUMMARY

A case of papillary adenolymphomatous and cystic tumor of the neck is reported. It

arose in the neck below the angle of the jaw and was removed surgically with ease. The tumor is readily diagnosed histologically because of the peculiar tall, columnar epithelium and lymphoid stroma. The tumors are of interest to the clinician and pathologist since after a tumor has been recognized as belonging in this category, the patient may be reassured that a recurrence is much less likely to appear than with other types of tumors involving the salivary glands.

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WHEN one is confronted by a simple colloid goiter of any age the possibilities exist that it is doing one of three things: nothing; becoming toxic; or degenerating and already cardiotoxic. When the goiter is doing nothing it speaks the language of a small boy; it has not yet done anything that can be discovered.

From—"Diseases of the Thyroid Gland. Presenting the Experience of More Than Forty Years"—by Arthur E. Hertzler (Paul B. Hoeber, Inc.).

# THE COURSE OF CARCINOMA OF THE THYROID GLAND\*

## REPORT OF AN UNUSUAL CASE

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THE present case of diffuse type of adenocarcinoma of the thyroid gland afforded the opportunity of studying, from the histological standpoint, not only the original tumor, but also the unhindered course of the remnants following its radical removal. Structurally, the tumor presents glandular elements of an undoubted carcinomatous nature together with cells having the appearance and arrangement suggestive of a sarcoma. An outstanding feature is the production of an enormous amount of hyaline material. Clinically, the case is of interest with respect to the age and condition of the patient and the size, position and growth of the tumor.

Neoplastic tumors of the thyroid gland are not too uncommon, although the exact incidence of malignancy is not known. In Switzerland, Wegelin<sup>1</sup> found one case of carcinoma of the thyroid gland in every ninety-six postmortem examinations. In the United States, carcinoma occurs about once in 928 autopsies.<sup>2</sup> Most clinics report an incidence of malignancy of about 1 per cent of all cases of goiter that come to operation and of 3 per cent of all adenomatous glands that are operated upon.<sup>2,3</sup> Nearly all malignancies of the thyroid gland are of epithelial origin and are for the most part of relatively low-grade malignancy. The majority are considered to arise from a gland having adenomatous changes. Occasionally, cancer develops in a gland considered normal or nongoitrous or in a hyperplastic gland of the exophthalmic type.

Sarcoma of the thyroid gland has been described by various authors.<sup>4-8</sup> However, actual acceptance of the true sarcomatous nature and connective tissue origin of a

tumor of the thyroid gland is not so widely acknowledged. It is well known that the cells of a carcinoma may in part resemble

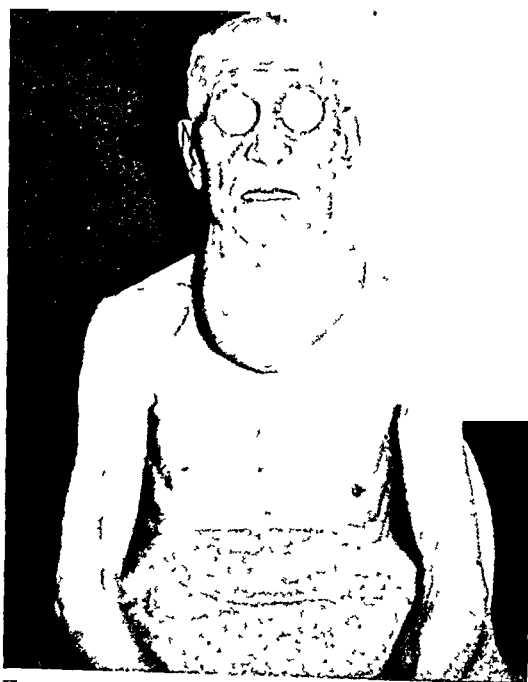


FIG. 1. Patient, age eighty-one, before first operation.

sarcoma. This holds true especially in tumors primarily of the higher grades of malignancy in which the follicular structure is less, or, perhaps less frequent than in tumors of the lower grades of malignancy in which smaller, more localized areas secondarily undergo changes indicative of increased malignancy and display cells of such shape and appearance that make their differentiation from sarcomatous cells difficult. The present case is an example of this type. Ewing, after a critical analysis of the subject of sarcomas of the thyroid gland, concludes "that the mesoblastic origin of most of the sarcomas reported in the

\* Read before the Brooklyn Surgical Society, May 2, 1940.



literature is highly improbable and that the occurrence of true sarcoma in man still requires demonstration."<sup>9</sup>



FIG. 2. Operative specimen 1; anterior view.



FIG. 3. Operative specimen 1; halved frontally, the surface is glistening, whitish and relatively uniform. The tumor was marble-like in appearance and almost cartilaginous in hardness. The appearance and consistency are due to the presence of the great amount of hyaline.

The diagnosis of carcinoma of the thyroid gland may be difficult at times. In general, any thyroid gland with known adenomatous changes displaying recent, evident increase in size, however small, should be regarded with suspicion. Many thyroid surgeons regard the mere presence of adenomatous changes in the thyroid gland as indicative of potential malignancy. Pain, tenderness to local pressure, increase in local firmness and irregularity of the surface, metastasis to adjacent lymph-nodes, pressure symptoms, capsular and contiguous tissue invasions are all usually relatively late manifestations. Constitutional findings are infrequent except in the late stages.

#### CASE REPORT

The present case deals with a piano-tuner, G. C., age eighty-one, who was admitted to the Cumberland Hospital on September 29, 1939, with complaints of swelling of the neck and difficulty in breathing.

As to the family history, the father died of "lymphoma" of the thyroid gland at the age of fifty-nine. One married daughter has carcinoma of both breasts at present.

In the past the patient had gonorrhea on two occasions as a young man. He has suffered with a diverticulosis of the bladder for the past fifteen years. Self-catheterization, four times daily, had been practiced for eight years because spontaneous voiding was not possible.

With respect to the present illness, the patient noticed the appearance and gradual increase in size of a mass in the neck on the left

side following a "severe nervous strain" about five years ago. It was not possible to determine whether a thyroid enlargement or a mass were present before that time. Beginning two years ago, hoarseness and difficulty in breathing were experienced. More recently, flexion of the head on the neck became limited because of the size of the tumor. There was no apparent local neck or chest pain. A mild, dry, irritative cough was present. Liquids and soft foods were swallowed more easily than dry, solid food. A loss of twenty pounds, attributable by the patient to limited food intake, occurred over the past two years. At no time in the past was there evidence of myocardial insufficiency. Lugol's solution, 2 m. daily, beginning three years ago, was taken up to three months ago.

On physical examination, there was seen a thin, poorly nourished, old man with a dry, wrinkled skin. Horner's syndrome was present on the right. The voice was hoarse and low pitched. In the neck, a 23 cm. wide, very hard, irregularly-shaped, grossly lobulated mass was found arising from the left lobe of the thyroid gland. (Fig. 1.) It extended roughly from ear to ear and from chin to manubrium. Because of its origin, size and firmly fixed position, it displaced markedly to the right the deeper midline structures, namely, the trachea and thyroid cartilage. The lateral edge of the hyoid bone could be felt directly under the right mandible at the angle of the jaw. The skin was slightly shiftable over the mass. The veins of the skin over the upper portion of the chest were prominent.

The mass overhung the manubrium anteriorly and limited somewhat the movement of the head on the neck, both vertically and

X-rays of the chest and neck areas displayed a flattened, displaced trachea in addition to several calcified areas in the lowermost portions

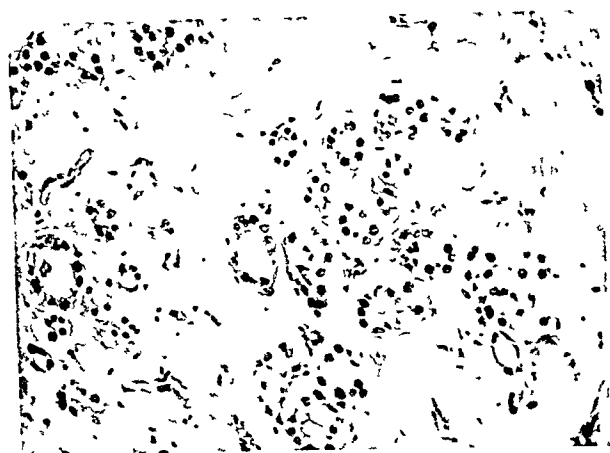


FIG. 4. A small area from the more central portion of operative specimen 1. This section was chosen to illustrate the process of coagulative necrosis and hyaline formation; careful scrutiny reveals numerous shadow forms of degenerating acini and cells. Other areas displayed a still greater degree of hyaline formation; peripherally the tumor acini were arranged in columns with broad, intervening hyaline areas. This glandular type of tissue and the hyaline material composed practically the entire bulk of the specimen. Reduced from a photomicrograph having a magnification of 300; hematoxylin and eosin stain.

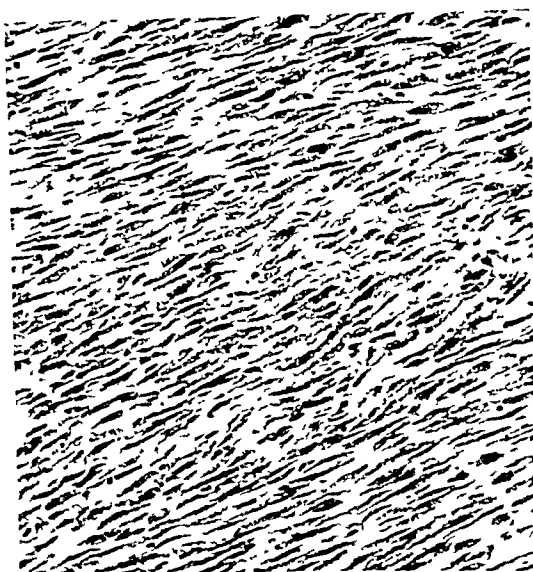


FIG. 5. Section taken from one of the occasional small areas of operative specimen 1 showing densely packed spindle-shaped cells arranged longitudinally. This type of tissue, with cells definitely more embryonal and hyperplastic in appearance. Reduced from a photomicrograph with a magnification of 300; hematoxylin and eosin stain.

laterally. An audible, low pitched stridor was heard on breathing through the open mouth. There was no tumor pulsation, tenderness or pain. Breathing difficulty was exaggerated by light, lateral pressure on the tumor. The chest was clear and the heart was markedly enlarged to the left. There were no murmurs and the rhythm was totally irregular. Extrasystoles were frequent. There was a definite pulse deficit. The abdomen presented no abnormal findings. There was present also a hypospadias and a moderately sized left, indirect, inguinal hernia. There was no ankle edema.

#### Laboratory data:

Temperature: 98°F.  
Pulse: apical 124.  
radial 110.  
Respirations: 20.  
Red blood cells: 4,100,000  
White blood cells: 6,800  
Polymorphonuclears: 70 per cent  
Lymphocytes: 26 per cent  
Monocytes: 4 per cent  
Wassermann: Negative  
Urine: occult white blood cells; faint trace of albumen  
Blood chemistry: normal  
Basal metabolic rate: Plus 21.8; weight: 117½ pounds.

of the above described mass. A cystogram showed "a large, definitely trabeculated bladder with numerous diverticuli." There were no demonstrable pulmonary, rib or spine metastases.

Following preliminary digitalization of the patient, the tumor was removed under intratracheal, cyclopropane anesthesia. Five hundred cc. of saline and 500 cc. of blood were infused during the operation. Throughout the operation the pulse rate was around 88, although the rhythm was mildly irregular; the blood pressure maintained at 120/80; its variation was negligible. The new growth was found to involve the left lobe of the thyroid gland; its lower third extended beneath the sternum and into the left chest. The trachea was markedly compressed and displaced to the right. The left sternocleidomastoid muscle was greatly thinned out and barely identifiable. Generally, the structures contiguous to the neoplasm were invaded by it and firmly adherent to it. Sharp dissection was needed in the main for the removal of the mass. At the end of the operation the midline structures had assumed a more normal position. A forty-

eight-hour iodoform wick was inserted in the depths of the wound. There was no breathing difficulty at any time during the operation;

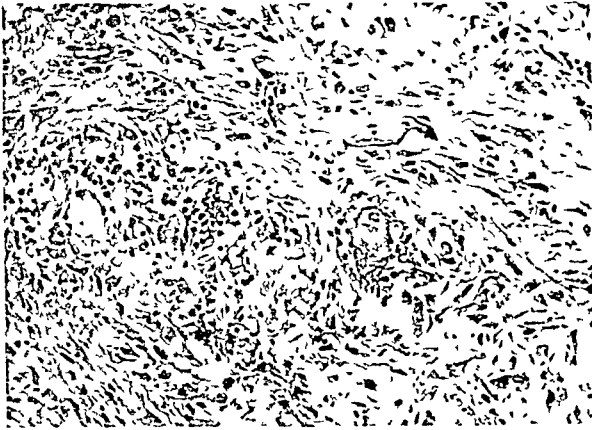


FIG. 6. Section of the single small area of operative specimen 1 displaying relatively widely separated cells of varying sizes and shapes suggestive of a mixed cell sarcoma. Just to the right of the center is a large irregularly formed acinus with eosinophilic staining colloid content.

the intratracheal tube was withdrawn about an hour after the completion of the operation.

Grossly, the removed tumor was roughly heart-shaped, measured 23 by 10 by 7 cm; and presented several large, irregular outgrowths, each of which displayed numerous smaller lobulations. (Fig. 2.) The tumor as a whole was very hard, unyielding and of an almost cartilaginous consistency. Numerous thin, shred-like tags of adjacent tissue were found to be firmly adherent to its surface. In its lower third an irregular, fairly well defined depression anteriorly divided the upper two-thirds from the lower third and roughly marked off the upper portion from the lower retrosternal third. On cutting the specimen in half, the sectioning knife met with a firm, cartilaginous-like resistance throughout the entire thickness. The cut surface was yellowish-white and presented a fairly homogeneous, glistening, somewhat opaque appearance with an occasional dull-reddish, soft area. (Fig. 3.) In the lowermost portions of the tumor several 1 to 2 cm. calcified areas were found.

Briefly described histologically, the tumor as a whole presented the picture of a diffuse adenocarcinoma of mild degree of malignancy. (Fig. 4.) Occasional small areas displayed dense collections of spindle cells. (Fig. 5.) The outstanding feature was the production of an enormous amount of hyaline material in the presence of a widespread, degenerative, coagulation necrosis.

Described in greater detail, the sections taken from representative portions of the tumor presented some variations as to the appearance of the acini, although in the main, they were small, relatively well rounded and somewhat closely packed, one to another; a tendency toward column arrangement of the grouped acini was frequent, especially in the more peripheral portions of the tumor where invasion of the capsule could be demonstrated. For the most part, the cells were flat to cuboidal; the intra-acinous spaces were small and not infrequently displayed small, irregular, deeply staining, eosinophilic, colloid collections. Mitotic figures were only occasionally seen.

A slow, degenerative, coagulation necrosis, presumably on the basis of impoverished blood supply, with marked hyaline formation, was widespread throughout the entire tumor. Peripherally, broad columns of the eosinophilic-staining material separated the described columns of tumor acini. Imbedded in the hyaline appeared relatively frequent, thin-walled, flattened, longitudinally placed blood vessels filled only partially with blood elements. The occasional areas of densely packed spindle cells were arranged longitudinally or in whorls. They presented occasional mitotic figures. A single small area displayed collections of relatively widely separated, irregularly shaped and sized cells suggestive in general appearance of a rather malignant mixed-cell sarcoma. (Fig. 6.) However, these collections gave evidence of their carcinomatous nature by the presence of scattered, irregularly formed acini with eosinophilic colloid content.

The immediate postoperative course of the patient was good. Most of his complaints were referable to the bladder condition. An indwelling catheter had been installed postoperatively. Within the first twenty-four hours it was noted that there was an almost complete disappearance of the prominence of the chest vessels. The patient stated that his head felt clearer. He ate without difficulty on the second postoperative day. At no time was there any difficulty in breathing. In fact, breathing appeared to be improved almost immediately postoperatively. The patient was up in a wheel chair on the fifth day and was walking on the seventh. He left the hospital on the eleventh postoperative day, at which time the apical pulse was 84 and the radial pulse was 80.

Despite repeated attempts to get the patient to return for planned postoperative irradiation, he persistently refused to return to the hospital.

A second operative procedure, similar to the first, with intratracheal anesthesia and supportive operative fluids and blood was



FIG. 7. The patient two and one-half months after operation. The fullness on the right at the level of the scar was suggestive of a recurrence.



FIG. 8. The patient four and one-half months after operation. The mass attained this size over a period of two months. In size and general appearance it resembles first tumor. In texture, however, it was more elastic and softer.

Follow-ups were maintained by personal visits to his home. Over the next two and one-half months his general condition was good. He stated that he felt well; there was a definite gain in weight. The pulse was mildly irregular; the pulse rate averaged 85. There was no evidence of decompensation. The structures of the neck were in the midline. Locally, beneath the lower flap anteriorly, at the end of two and one-half months, a small, moderately firm mass could be felt. (Fig. 7.) It was suggestive of a local recurrence.

Following this, over the next two months, the small mass continued to enlarge with alarming rapidity so that four and one-half months after the first operation, it had attained a size almost as large as it was preoperatively. (Fig. 8.) At this time, after much persuasion, the patient returned to the hospital. The symptoms were essentially the same as before the first operation. Breathing difficulty with mild cyanosis were present; x-rays of the neck again displayed a marked tracheal compression.

carried out on February 15, 1940. The operative procedure *per se* was handled only fairly well. The operative findings were similar to those of the first procedure.

On this occasion, a grossly lobulated 20 by 15 by 8 cm. tumor was removed. In contrast to the first operative specimen, the second specimen was softer, friable and extremely cellular. Further, histological study showed that the tumor, almost in its entirety, was composed of actively growing spindle cells, the glandular elements being in the minority and found only in occasional small areas. Mitotic figures were not infrequent.

About four hours postoperatively, the patient died, presumably from cardiovascular collapse and delayed shock. Necropsy performed a few hours later, disclosed metastatic involvement of the peribronchial and peritracheal lymph-nodes. In addition, there were several small metastatic nodules just beneath the pleura of both lungs. As in both operative specimens the metastases displayed glandular

elements with formed acini in addition to areas showing spindle-shaped cells.

#### SUMMARY AND COMMENT

A case has been described of a diffuse adenocarcinoma of the thyroid gland in an old man, age eighty-one.

Clinically, the case illustrates the operative possibility for the relief of tracheal compression in the seemingly hopeless, inoperable type of case in which primary irradiation of a tumor, composed for the greater part of hyaline material, would not be effective.

Pathologically, it reconstructs the course and growth, presumably from a gland with adenomatous changes, of a primarily mildly malignant adenocarcinoma, with late invasion of the capsule by the glandular elements, and final rather marked increase in malignancy and the cellular assumption of a more embryonal state in localized, smaller areas. Later still, following the radical removal of the tumor, an astonishingly rapid growth of the remaining malignant elements took place. The recurrent tumor, in the greater part, was composed of rapidly growing spindle cells. The outstanding feature of the original tumor was

the enormous production of hyaline material. Further, the tumor illustrated its fundamentally carcinomatous nature in the metastases in which were found both formed acini, with eosinophilic colloid content, and areas of spindle-shaped cells.

Finally, it appears reasonable to assume, on the basis of the cellular character of the recurrence, that its growth could have been inhibited by irradiation following the first operative procedure.

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# LARGE TUMOR OF VAGINA

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**L**EIOMYOMA of the vagina is a comparatively rare tumor. Up to 1930 there were 270 reported cases in the literature. In almost all of the reported cases the tumors were small, many not larger than a walnut. Eighty per cent are located on the anterior vaginal wall. They occur mostly between the third and fourth decades of life and are usually single and benign.

This case is of unusual interest because of the large size of the tumor:

## CASE REPORT

A white female, age fifty-five years, complained of inability to urinate at times which progressively became worse for the past three months. Physical examination revealed a middle aged, obese female. Her eyes reacted to light and accommodation; her teeth were in poor condition with many cavities. Tonsils were small and atrophic and her neck was obese and no tumor masses were found. The heart was normal in size and position, no murmurs, and good tone. The lungs were normal with no audible râles. The abdomen was prominent but no tumor masses were palpable. The labia were normal. The perineum was relaxed; there was a protrusion at the vagina which resembled a rectocele, but on palpation it felt like a large tumor deep in the pelvis behind the mucous membrane of the vaginal wall. On rectal examination a large tumor mass could be felt deep in the pelvis. The extremities and reflexes were normal.

The urine showed a small amount of albumin. The hemoglobin was 60 per cent. The leukocytes were 7,000; red cells 3,600,000. A transfusion of 600 cc. of citrated blood was given the day before the operation.

The preoperative diagnosis was fibroid tumor deep in the pelvis originating from the uterus. (Fig. 1.)

**Operation.** A low midline incision was made. The uterus and cervix were small; tubes

and ovaries were normal. Then with one hand in the pelvis and the other hand in the vagina I was able to outline the vaginal mass which

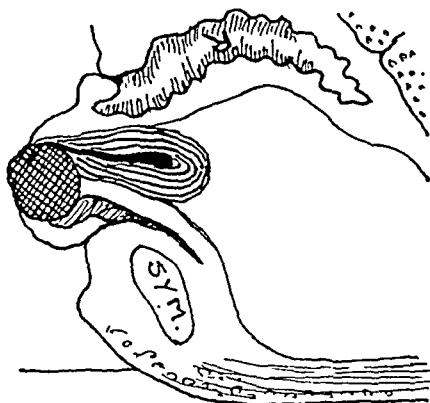


FIG. 1. Illustration of tumor.

was as large as an ordinary grapefruit which completely filled the vagina. The mass was attached to the anterior vaginal wall, just anterior to the cervix and extended to the urethra. A sterile towel was placed over the abdominal incision and the patient placed in the lithotomy position. By placing retractors in the vagina a line of cleavage was found and the tumor mass separated from the anterior vaginal wall. Because of the large size of the tumor, it had to be split in the midline and the two pieces removed separately. All bleeding points were clamped and a pack placed in the vagina. After inspecting the pelvis from above for injury the abdominal incision was closed in layers.

The pack was removed in twenty-four hours. On the fourth day the patient began to urinate and made an uneventful recovery. When last seen, one month later, she seemed perfectly normal. Pathological report: leiomyoma.

## SUMMARY

Leiomyoma of the vagina are comparatively rare tumors. They are usually small and are located principally on the anterior vaginal wall. This case is of special interest because of the large size of the tumor.

# New Instruments

## BEDSIDE HEAD REST FOR EMERGENCY HEAD INJURIES\*

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IN our "all-out" attack upon the problem of head injuries which we are bound to encounter during this war and unexpected attack upon Hawaii he frankly states that the number of such injuries to be treated was so large, that it was neces-

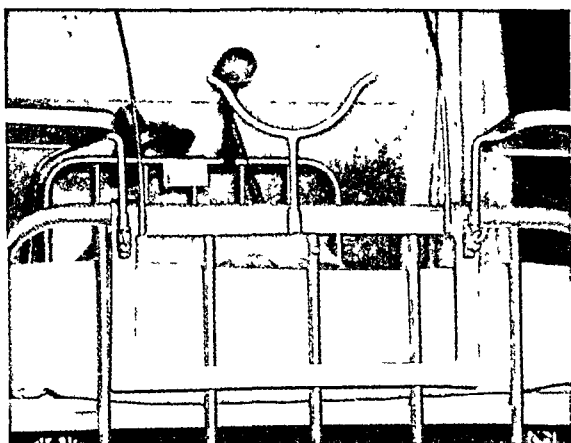


FIG. 1. Close-up view of apparatus attached to the foot of usual hospital bed.

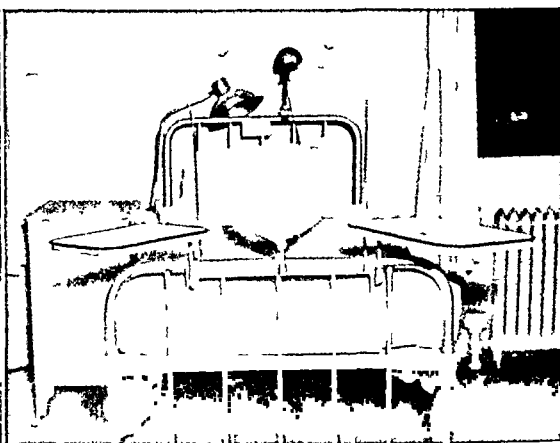


FIG. 2. Front view of padded head rest with trays and head screen.

possibly during air raids, it will be necessary to modify some of our tactics in the treatment of such patients.

Reliable statistical data as to the incidence of head injuries on the present various battle fronts or during air raids are as yet unobtainable. Exact numbers or percentages of casualties are apparently withheld for military reasons. However, from recent British reports head injuries are admittedly high. Olivocrona<sup>1</sup> in referring to the injuries during the war from 1914 to 1918 states that about 50 per cent of those who died on the battlefield had been shot in the head or neck, and that of the casualties passing through first aid stations 15 per cent were head injuries. In Cloward's<sup>2</sup> recent report of head injuries during the

sary in many instances to delay operation twenty-four to thirty-six hours after the injury.

Since many patients with head injuries may have in addition wounds to other parts of the body, shock treatment will have to be started almost immediately. Indeed one must learn, re-learn, and keep on reminding oneself that "shock" treatment comes first. Well organized "shock" teams will save many lives.

We are all aware of the many factors which aggravate surgical "shock." Rough handling and unnecessary transportation are two of the most serious offenders. To eliminate their harmful effects we must organize our various surgical units, so that in so far as it is possible, the benefits of the

\* From the Neurosurgical Service, Mt. Sinai Hospital, New York City.

operating room will be brought to the patient, rather than have the patient brought to the operating room.

ing out of serious casualties. As an aid to the practical sorting out of head injuries, to the elimination of unnecessary trans-



FIG. 3. Side view of apparatus showing shape and slope of screen.

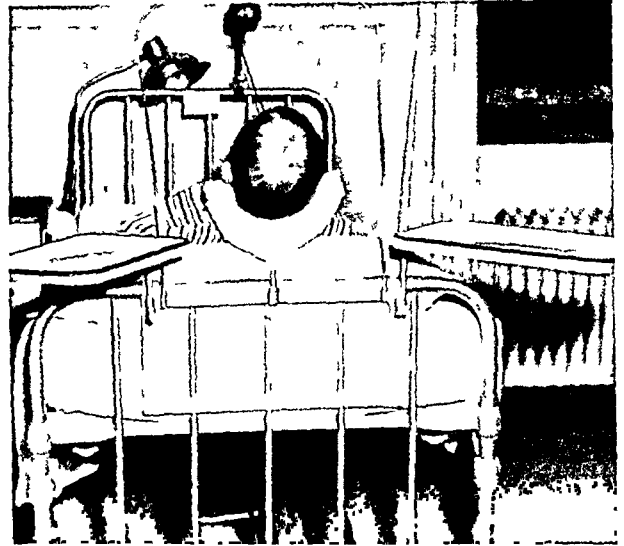


FIG. 4. Patient in proper position with head fully exposed.

portation of patients, and to the facilitation of the treatment of many minor and some serious head injuries, the following bedside head rest is described and recommended.



FIG. 5. Side view with patient in position.



FIG. 6. Drapes applied exposing operative side. Note covering of trays.

Even during a minor catastrophe the operating rooms of most of our large hospitals will be taxed to capacity, and much will depend upon a rapid and realistic sort-

The apparatus consists of a curved head piece which is padded, with two adjacent trays of unequal size which can readily be rotated to the desired position, and a screen



for sterile drapes. (Fig. 1.) The apparatus is attached to the foot of the usual hospital bed with a minimum of effort (Figs. 2 and

The sterile field now allows for simple wound cleansing or débridement. This setup may also prove satisfactory for more



FIG. 7. Full view of patient's face. This position is also convenient for additional treatments.

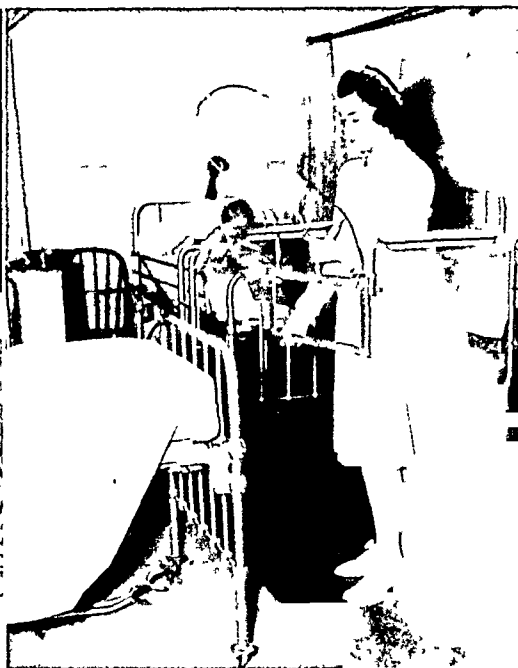


FIG. 8. Note how easily apparatus can be transferred from the foot of one bed to another.

3) and is so constructed that it will not tilt or slide.

The entire apparatus weighs about 12 pounds, 8 pounds without the trays, and the frame alone weighs 5 pounds. The parts are detachable and they can be shifted separately from the foot of one bed to another.

As the patient's head is placed toward the lower end of the bed he can easily be lifted so that this neck rests in the hollow of the padded head piece. (Figs. 4 and 5.) In this position the entire head can be gently rotated and inspected, the hair clipped and the scalp shaved.

With this exposure any scalp injury or hematoma can hardly escape detection. The scalp can then easily be prepared. A sterile drape (Fig. 6) is applied to encircle the site of injury, which at the same time covers the adjacent trays. The arrangement of the drape permits the nurse, who is in a good position to assist in manipulating and steadying the head, to have a full view of the patient's face. (Fig. 7.)

elaborate procedures by those specially trained.

After the wound is dressed, the patient is lifted back gently upon the pillows which are at the foot of the bed. The apparatus can now be detached and transferred with ease to the next bed. (Fig. 8.)

It is advisable to have several sets of these bedside head rests\* which can be used in rotation with the assistance of a surgical nurse in sterile uniform. This nurse remains surgically clean and is in charge of a cart supplied with sufficient equipment for a number of cases. With such organization many head injuries of considerable severity can be efficiently treated with speed, simplicity and a minimal of shock.

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\* The apparatus with minor modifications is also suitable for treatment of injuries about the face, and can even be used for foot or leg injuries with the patient in proper position.

# A SIMPLE APPARATUS FOR THE ADMINISTRATION OF PENTOTHAL SODIUM OXYGEN ANESTHESIA BY ONE ANESTHETIST

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**I**NTRAVENOUS anesthesia frequently requires the services of two anesthesiologists. This has retarded the use of pentothal sodium oxygen anesthesia even though it is recognized as an aid in both major and minor surgery. I have been using for over a year a simplified apparatus which permits one anesthetist comfortably to inject 2.5 per cent pentothal sodium intravenously and at the same time administer oxygen. The apparatus has the added advantage that the patient's arm may be abducted on an arm board or kept at the side. It is composed of a No. 20 gauge  $1\frac{1}{2}$  inch intravenous needle, a glass observation tube, 30 inches of small gauge special rubber tubing such as is used in a fractional spinal anesthesia apparatus, a stopcock, and a 50 cc. Luer-Lok syringe which will fit the stopcock. A stand which will fasten onto any operating table is used, and attached to it is a swivel jointed burette holder which permits the syringe to be clamped at a convenient height or angle.\* When the apparatus is used with the patient's arm held at the side we have found that there is less chance of dislodging the needle if it is inserted prox-

imally and the tubing then curved back on itself by means of a piece of metal suitably fashioned.



FIG. 1. Apparatus for the administration of intravenous anesthesia.

The induction of anesthesia is rapid and rarely have we seen a needle become dislodged. Back flow of blood into the observation tube does not occur. This fact combined with our technic of giving minute injections at frequent intervals results in even anesthesia and only rarely in an occluded needle.

\* This apparatus is supplied by the George P. Pilling Company, Philadelphia.



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## Selected Book Reviews

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**D**URING the past few months many excellent books on various medical topics have been published. This month, instead of a long review of only one book, we are offering short, thumbnail reviews of what we believe are recent outstanding publications.

In gynecology we have Novak's "Gynecology and Female Endocrinology."\* In about 600 pages the author has given us one of the best and most satisfying works on these subjects to date. Although the student may refer to several excellent books on gynecology, we place Novak's work at the head of the list. It has been cut to the bone and has not a single page of padding; nevertheless, it is complete and is very well written. The profuse illustrations truly illustrate the text and the colored pictures are splendid. Purposely, the author has omitted the details of operative technic. Worth-while and recent references are at the end of each chapter and the index is adequate. Both author and publishers are to be congratulated in offering at this time, when the world is topsyturvy, an up-to-the-minute, readable, authoritative and scientific work on gynecology and female endocrinology.

Should one wish for a complete work on "Malignant Disease and Its Treatment by Radium" we refer him to a book of that title by Stanford Cade.† It is a large book (nearly 1,300 pages) and has 623 illustrations, many in color. The author writes: "Successful treatment (of cancer) depends upon three main factors: a sound knowledge of the disease; a wise selection of the method of treatment; and accurate and skillful technique." Covering a period of fifteen years the author saw about 4,000 cases of malignant disease; of these about 3,000 patients were treated by radiation either as the sole method of therapy or in combination with surgery. A record of each case was kept from the very beginning. The material

\* Gynecology and Female Endocrinology. By Emil Novak, A.B., M.D., D.Sc. (Hon. Dublin), F.A.C.S. Boston, 1941. Little, Brown and Company.

† Malignant Disease and Its Treatment by Radium. By Stanford Cade, F.R.C.S. Baltimore, 1940. The Williams and Wilkins Company. Price \$18.00.

thus gathered laid the foundation for this volume. If one can afford the price, this volume is worth owning. A careful study of its pages will bring one up-to-date on the diagnosis and treatment of malignant disease.

"Preeclamptic and Eclamptic Toxemia of Pregnancy"\* is a book for the man who does obstetrics. It is a short, concise work (398 pages) by Lewis Dexter and Soma Weiss. Dr. Dexter is Research Fellow in Medicine at the Harvard Medical School. Soma Weiss, also of Harvard, died recently. He was one of the "great" physicians and he died a very young man. The book was written in collaboration with Florence W. Haynes, Herbert S. Sise and James V. Warren.

This monograph is based on an investigation of preeclamptic and eclamptic toxemia of pregnancy conducted over a period of three years. The investigation was stimulated by many confusing problems confronting one of the authors during the fourteen years he acted as the medical consultant of the Obstetrical Service of the Boston City Hospital.

The student will find a full bibliography at the end of each chapter and obstetricians would do well to read this text carefully.

The lay press gave Gregory Zilboorg's "A History of Medical Psychology"† high praise. No author could wish for more laudatory reviews, and from a professional viewpoint we can echo these praises. The title tells us what the book is about, and a perusal of its contents will convince the reader that he is deep in the pages of a rare and delightful work. One need not be a physician to enjoy this history of man's long struggle with mental illness, but physicians are sure to get the "something more" from its pages than any layman. We recommend this work for reading during that half hour before bedtime.

If we had our way we would have every surgical intern, resident and young physician in practice own a copy of Ferguson's "Surgery of the Ambulatory Patient."‡ When one considers the thousands

\* Preeclamptic and Eclamptic Toxemia of Pregnancy. By Lewis Dexter, A.B., M.D. and Soma Weiss, A.B., M.D. Boston, 1941. Little Brown and Company. Price \$5.00.

† A History of Medical Psychology. By Gregory Zilboorg, M.D. In Collaboration with George W. Henry, M.D. New York, 1941. W. W. Norton Co., Inc. Price \$5.00.

‡ Surgery of the Ambulatory Patient. By L. Kraeer Ferguson, M.D., F.A.C.S. Philadelphia, 1942. J. B. Lippincott Co. Price \$10.00.

of physicians, general practitioners and budding specialists, who see the great majority of the surgical ills of mankind that are labelled minor or ambulatory, it would be well for all of these to become expert and know the "right answers" which are to be found in this work.

This is a complete book (over 900 pages) and covers every conceivable injury and anomaly. It is profusely illustrated. In section one we are told how a room should be equipped to handle the surgery of the ambulatory patient, what anesthesia to employ, how to prepare for and conduct an operation on such patients, pre- and postoperative care, dressings and bandages, burns, foreign bodies, open wounds, superficial cysts and tumors. Section two deals with regional surgery and the third part of the book considers the musculoskeletal system. We suggest that those who are engaged in this type of work own a copy of Ferguson's work. They will refer to it often and many will read it from cover to cover.

"A Textbook of Surgery by American Authors," edited by Frederick Christopher is offered in a third edition, which has been completely revised and reset. This outstanding work,\* first published in 1936, is the result of the contributions of almost two hundred American surgeons. Their names make a long Who's Who of the cream of our profession.

Suffice it to say that this is a textbook in every sense of the term and covers the surgical field from "abdominal distention" to "zygomatic bone fractures." It has 1,718 text pages and a long index. The illustrations are not too many and are of a high order. It is just the book to have on a library shelf for handy reference or to read on subjects that particularly interest one.

In the Foreword of his book the author, Dr. Goodrich C. Schaefler, writes: "In 1925 I saw a little girl of three with gonorrheal vaginitis. Until that time I had not examined prepubertal female genitalia. I had been taught nothing concerning them in medical school, during my internship or even during a specialized residency in obstetrics and gynecology. So I went to the texts and found only fragmentary and uncoordinated information. . . . The obvious need for more adequate information suggested study."

\* A Textbook of Surgery by American Authors. Edited by Frederick Christopher, B.S., M.D., F.A.C.S. Third Edition. Philadelphia, 1942. W. B. Saunders Company.

As a result of this study we have a much needed work,\* "Pediatric Gynecology." The author covers psychological factors in the management of a child, gives a detailed description of the external genitalia and vagina, and goes thoroughly into their defects, discussing disorders during adolescence and the onset of menstruation, preoperative, operative and postoperative management, special urologic and proctologic considerations, and at the end of the book the author devotes a chapter to social service (written in collaboration with Mary L. Eggleston—most physicians will learn a lot from reading this chapter) and medicolegal aspects. The author closes with a consideration of basic standards of hormone units and state agencies administering child welfare services.

This pioneer book, full of practical facts, contains sixty-six illustrations and is instructive and interesting. The gynecologist will be rewarded in studying its pages, and to general practitioners of medicine, who see pediatric gynecologic conditions so often, the ownership of this work comes under the heading of a "must."

Every gynecologist is familiar, or should be familiar, with the history and work of the late Joseph Price. His pupil and successor, James William Kennedy, has carried on certain underlying principles as laid down by Price. Not the least of these has been the technic for vaginal hysterectomy. For many years the great majority of those engaged in gynecological practice listened to the plea for removal of the uterus via the vaginal route but continued to follow the abdominal technic. Within recent years, however, more and more operators have resorted to the vaginal route, and today, vaginal hysterectomy in many clinics is routine and not the exception to the rule. For this we can thank Dr. Kennedy. And so we welcome his thorough work† on this subject.

Suffice it to say that the authors (James William Kennedy and Archibald Donald Campbell) have considered every phase and aspect of the subject. They discuss vaginal hysterectomy versus abdominal hysterectomy, use of the cautery, and many other topics, such as cystocele and rectocele in procidentia, cervical polyp, the infected puerperal uterus, malignancy, vaginal removal

\* Pediatric Gynecology. By Goodrich C. Schauffer, M.D. Chicago, 1942. The Year Book Publishers, Inc. Price \$5.00.

† Vaginal Hysterectomy. By James William Kennedy, M.D., F.A.C.S. and Archibald Donald Campbell, F.R.C.S., F.A.C.S. Philadelphia, 1942. F. A. Davis Company. Price \$10.00.

of the cervic, pre- and postoperative care, and also go into detail regarding the technic of their operation. Louis E. Phaneuf wrote the Foreword and the work is rich in illustrations.

"The History and Evolution of Surgical Instruments,"\* is a collector's item. In addition, it should appeal to the historian, to those who love and cherish nice things, the unusual and the rare, and who want these rarities in their libraries.

Many know of the remarkable collection of surgical instruments that were kept at the Royal College of Surgeons of London. But not many know that during the Nazi bombings the Royal College of Surgeons' building facing the beautifully parked Lincoln's Inn Fields was hit and this priceless collection of surgical instruments and also whatever records there were available to describe them were destroyed. Fortunately, Dr. Thompson, who needs no introduction to American readers, had thoroughly studied this material and had prepared this comprehensive survey. Parts of this book have appeared in the *British Journal of Surgery*. Chauncey D. Leake, who wrote the Introduction, concludes; "While this historical survey can never supplant the instruments themselves, it will serve to perpetuate the purpose of the collection, and to carry forward the humanitarian function of the Royal College of Surgeons in preserving the record of the developing technique of surgical art, so that all who appreciate it may profit from it. Dr. Thompson's book thus becomes another thrilling justification of the faith that no matter how powerful or insane the instruments of destruction may become, there is certain to remain an effective knowledge of the instruments of mercy and peace."

Henry Schuman has prepared a beautiful book that is a delight to hold and look at. Only 1,000 copies of this edition have been printed. Needless to say the author has written an absorbing and true history of the scalpel, amputation knife, saw, trepan, vaginal dilator and speculum, head-saws, artery and dressing forceps, bullet forceps and extractors, instruments for phlebotomy and venesection, tourniquets, trocars and operating tables. The book is well illustrated and there is an ample index.

\* The History and Evolution of Surgical Instruments. By Dr. C. J. S. Thompson. New York, 1942. Schuman's. Price \$8.50.

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## Editorials

### LIMITATIONS AND POSSIBLE HAZARDS OF ENDOCRINE TREATMENT IN GYNECOLOGY

GYNECOLOGISTS have long prided themselves that their own particular segment of the rich field of endocrinology has been more productively worked than has almost any other. While this is probably true, the explanation is that gynecology has profited by the fortuitous circumstance that it is so largely concerned with disturbances of the female reproductive phenomena, and that amazing advances have been made in our knowledge of the endocrinology of this intricate reproductive mechanism. In these advances many gynecologists have been eager allies of the laboratory investigators who deserve the chief credit for the advances made during the past quarter century or so.

The endocrine treatment of functional gynecological disease, if it is to be rational, must conform, insofar as possible, with what appears to have been established by sound investigative methods, so that it is no longer necessary to emphasize that the well trained gynecologist must be familiar with the fundamentals of female endocrinology. There are still many gaps in our knowledge, and it has long been clear that many of the results of animal experimentation cannot be applied to the animal with which the gynecologist works, the human

female. Realization of this fact has in recent years done much to lessen the enthusiasm of our attempts to apply clinically the steady stream of new knowledge flowing from the laboratories. I well recall the eagerness with which the discovery of the "female sex hormone" was greeted as possibly solving such tough therapeutic problems as the treatment of amenorrhea, and of the aftermath of clinical disappointment. The same disillusionment came after the brilliant laboratory demonstration of the domination of ovarian function by the gonadotropes of the pituitary. After fifteen years these hormones have not yet been isolated, and the gonadotropic principles as yet available have not materially improved our clinical results in the treatment of such disorders as amenorrhea and sterility, in certain types of which they would reasonably be expected to be of help. These examples might be multiplied.

A very large proportion of the thousands of papers which have been devoted to the therapeutic applications of the endocrines in gynecology are obviously unsound and uncritical, serving only to mislead the uninformed reader and perhaps to disgust those better qualified to detect the fallacies with which they so often abound. Nor are the skirts of laboratory investigators al-



together clean, for their literature likewise is richly spotted with "scheinwissenschaft," to borrow a term from the language of our present enemies.

For clinicians especially a hard-boiled skepticism is certainly a safer attitude than the naive overenthusiasm exhibited by many writers, and yet it may be overdone. There are some who appear to have cultivated a pose of extreme skepticism, even in the face of genuine knowledge honestly arrived at, simply because such an attitude, mistakenly labeled as conservative, appears impressive and oracular. A few writers have been consistent and sincere "debunkers," and they have done much to counteract the baneful influence of misguided enthusiasts, aided and abetted by some of the less scrupulous manufacturers of gland products.

With no thought of assuming the oracular rôle which has just been criticized, I should like to set down, in a rather aphoristic fashion, a few items which serve to illustrate the limitations and even possible hazards of gynecological organotherapy. This list, which could be expanded at considerable length, has to do with the negative side of the endocrine ledger. There is no attempt at elaboration or controversial discussion, but I believe that the statements made will be endorsed by all well informed gynecologists and endocrinologists; some are almost trite:

1. Now that the two ovarian hormones, estrogen and progesterone, are readily available in pure form, there is no excuse for the use of the old fashioned tablets, capsules and solutions of ovarian substance, ovarian residue or corpus luteum which formerly were so universally employed in the treatment of ovarian deficiency, real or supposed. If this seems to be an unnecessary injunction, let me remind the reader that considerable quantities of such preparations, almost or entirely lacking in hormonal activity, are still produced by even high-grade manufacturers, simply because of the demand for them by physi-

cians who have failed to keep up with the times.

2. The estrogenic substances do not stimulate the ovary, and in large doses they inhibit its function, so that their administration cannot be expected to start the ovarian mechanism. Their employment in the treatment of amenorrhea is therefore substitutional, and it rarely enhances the patient's chances for correction of the sterility which is so commonly associated with endocrinopathic amenorrhea.

3. The valuable new nonhormonal chemical stilbestrol should still be handled circumspectly, but there is every reason to believe that in proper dosage its use is perfectly safe. When thus used the incidence of unpleasant but not dangerous toxic symptoms is much lower than was noted in the days of its experimental use, when unnecessarily large doses were often employed. Personally, I believe this substance to be a genuine boon in the treatment of menopausal symptoms, in view of its inexpensiveness and its high degree of estrogenic potency by oral administration.

4. There has been much discussion and considerable apprehension concerning the possibility that estrogenic therapy might in some cases lead to the development of cancer. The question is too big a one to discuss here in all its angles. Suffice it to say that there is no worth-while evidence to indicate that the estrogens in any reasonable therapeutic dose can have any such effect in the human. Even large doses have appeared to carry no such hazard, but the wise clinician will nevertheless avoid unnecessarily large or promiscuous estrogenic dosage, perhaps even more for other reasons than because of a cancer hazard. He will certainly wish to be circumspect in the employment of estrogens in patients in whom, either on the basis of family history or because of the existence of some precancerous lesion, a predisposition to cancer may be properly suspected. On the other hand, it would seem far-fetched and unjustified, in the present state

of our knowledge, to deprive women of the often very real advantages of estrogenic treatment because of the vague specter of cancer hazard.

5. No gonadotropic principle of undoubted efficacy in the human is as yet available. Efforts to prepare such active extracts from the pituitary gland itself have thus far been unsuccessful. The effect of various gonadotropic principles on the human ovary has yielded no clear-cut evidence of distinctive effects, and many good observers have reported no worthwhile effects of any kind. It is not surprising, therefore, that the clinical results with preparations of this general group have been so generally disappointing.

6. One of the most abused of all forms of endocrine therapy during the past few years has been the indiscriminate use of the equine gonadotropic principle, obtained from pregnant mare serum, in the treatment of sterility. The offense is particularly flagrant when such treatment is resorted to, as it often is, without proper preliminary investigation as to the possible causes of the sterility. In only a small proportion of cases, more especially those of so-called anovulatory type, is there a justification for treatment of this sort, and even in this group the results are disappointing. There is no certainty that even harmful results may not be caused by the careless use of these preparations.

7. The employment of various hormones in the treatment of certain cases of primary dysmenorrhea and functional bleeding is justified and indicated. This is not the place to discuss details, but it is the place to emphasize that a great many disappointments are bound to be encountered in the treatment of both of these disorders, if endocrines are relied on to the exclusion of other measures. This is particularly true with dysmenorrhea.

8. The employment of androgenic hormone principles, usually in the form of testosterone propionate, has achieved wide

vogue in the treatment of certain cases of functional bleeding and primary dysmenorrhea, and the results frequently justify the method. The fact that hirsutism and other masculinization symptoms may at times occur has made many clinicians hesitate in employing this substance. Certainly, the dosage employed by some has been too large, with much greater risk of unpleasant sequelae under such circumstances. The available evidence would indicate that with smaller doses, usually not exceeding 200 mg. a month, and often much less, the risk is very slight. The possibility of these sequelae, transitory though they may be, is nevertheless a genuine disadvantage of this treatment, and it should certainly be avoided in patients who already have a tendency to hypertrichosis or excessive pigmentation.

While some of the above comments may seem quite pessimistic, there is, as a matter of fact, no reason for discouragement as to what has actually been accomplished in this field within our own generation, far more than was accomplished in all preceding generations put together. However, these accomplishments are pretty well emblazoned in the literature, while the limitations and hazards of organotherapy will still bear frequent re-emphasis. It is lamentable but true that many physicians too quickly and too indiscriminately resort to "shots" of one form or another without adequate study of the individual problem, and without making an effort to acquire at least an elementary knowledge of female endocrinology. Without the latter, intelligent organotherapy is simply out of the question; and even when endocrine therapy appears to be intelligent, it is all too frequently disappointing. Nothing is more certain, however, than that our rapidly growing knowledge of endocrinology and biochemistry will with each year yield a measure of improvement in therapeutic results.

EMIL NOVAK, M.D.

I THINK there is no more opportune time to write on this subject than now. What with a new war and with the increasing accidents, this subject can well be considered.

Since 1902, I have indulged in the practice of industrial or traumatic surgery. During the past war I was fortunate enough to be assigned to the British army and eventually taught bone and peripheral nerve surgery in the hospital, an experience which was very much to my benefit.

Many times since my return young and older doctors have asked me where they could go to obtain a post-graduate course on this subject as well as occupational diseases, which is now a part of the compensation laws of almost all the states in our country. I was unable to give them any tangible answer.

When Dr. Franklin Martin was living he called a meeting in Chicago of a number of men doing this work. At this meeting were deans of three universities. Dr. Martin's question was: What could be done to introduce this department? I was the first called upon. I frankly stated that the first criticism would lie at the door of the medical schools in that they did not have a chair competently filled by one who could and would teach the subject. Graduates came to me asking for an opportunity to work with me because they did not get sufficient training in their schools and I still get the same complaint.

At that time I had eight assistants in my office from different schools and it was deplorable what they did not know about the technic of the reduction of fractures, the proper application of splints and the treatment of other types of bodily injuries.

To my surprise at this meeting two other very competent industrial surgeons got up and more than doubted what I had said. This produced some consternation. Dr. Martin asked the deans about this and they frankly admitted they had not concentrated on the matter.

I believe that if we had in the larger cities in this country a hospital devoted to nothing but traumatic surgery and

occupational diseases, it would be a boon not only to the general practitioner but the injured man as well. And if included in that hospital was a layman who could teach the business end and show the post-graduate student how to make out and follow up reports, it would be invaluable to the companies who depend upon the doctor to know just what the situation is. There is no doubt in my mind but that the industrially trained doctor would be only too glad to go on the staff of such an institution for the good of humanity alone.

Incidentally, such highly trained men would get referred surgery from the country practitioner when the latter got into deep water, which we all do no matter how well trained. The man who will not accept consultation when advisable is a menace. A hospital of this kind in the different cities would make it more accessible to the local man who has little time to spare and cannot meet the expense of a long trip. He would also learn the compensation laws of his own state.

Many readers will probably say their hospital is completely equipped with everything germane to this subject. Such is not the case, for I have been in many hospitals in this country and they do not have the equipment, while an industrial hospital in the different cities would have to have it or cease to exist.

Somebody may say "That is fine, but who is going to build that hospital?" My first answer is that in all the larger cities there is some man of wealth who wants to perpetuate his name. I do not think a finer thing could be done by such a man than to put his money into such an institution and have it called the John Jones Industrial or Traumatic Hospital. The other angle would be general contribution.

Finally, as medical men we should be big enough to accept this situation instead of trying to centralize it all in one or two institutions. I talked to a number of young graduates as well as older men and without exception they were all enthusiastic both for the schools and hospitals.

C. R. G. FORRESTER.

\*Since the writing of this editorial, Dr. C. R. G. Forrester passed away.

# *The Dawn of Abdominal Surgery*

BY DEAN CORNWELL, N. A.



*Courtesy John W. Zeth & Brother, Philadelphia*

## *The Dawn of Abdominal Surgery*

*Doctor Ephraim McDowell about to perform the first ovariectomy  
on Jane Todd Crawford, Danville, Kentucky, 1809.*

BY DEAN CORNWELL, M. D.

FOURTH IN THE SERIES "PIONEERS OF AMERICAN MEDICINE"

## THE DAWN OF ABDOMINAL SURGERY\*

EPHRAIM McDOWELL PERFORMING THE FIRST OVARIOTOMY  
ON JANE TODD CRAWFORD IN DANVILLE, KENTUCKY, 1809

DEAN CORNWELL

IN the fall of 1809, Dr. Ephraim McDowell, a young surgeon trained at Edinburgh, who had set up practice in the pioneer community of Danville, Kentucky, was called to examine a Mrs. Jane Todd Crawford who lived at Greenville, Kentucky, sixty-five miles from Danville. Her local physicians had examined her and diagnosed a pregnancy but the woman's term was overdue and they could not effect a delivery. Dr. McDowell diagnosed the condition as ovarian tumor and after consulting with the woman and her husband, Mrs. Crawford agreed to go to McDowell's home in Danville and be operated upon. Early in December, 1809, Mrs. Crawford rode on horseback the sixty-five miles to Danville and on Christmas Day, 1809, she was operated upon in a second floor room in Dr. McDowell's own home.

History does not record any successful abdominal operation up to this time and the consensus of medical opinion was opposed to it. Within the next few years, however, Dr. McDowell performed the same operation thirteen times, eight of which were successful. But neither this operation nor any other abdominal procedure was commonly accepted in general practice by the medical profession for another fifty years.

Mr. Cornwell went to Danville last fall and spent a full day sketching in the very room in the McDowell home in which the operation was performed for the purpose of getting the proper background. The artist also made two trips to Washington, D. C., using the well known statue of McDowell, presented by the State of Kentucky to the Capitol Building, as one of the sources for the surgeon's portrait.

These colored inserts have been supplied through the courtesy of the John Wyeth & Brother, Inc.

\* "The Dawn of Adominal Surgery," which constitutes the fourth large painting in the series, "Pioneers of American Medicine," painted by Dean Cornwell, will be unveiled at the Annual Convention of the American Medical Association at a luncheon on Monday, June 8, at Hotel Traymore, Atlantic City, New Jersey.

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# Original Articles

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## THE SYNDROME OF THE ROLANDIC VEIN\*

(HEMIPLEGIA OF VENOUS ORIGIN)

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### INTRODUCTION

THE disturbances, resulting from interference with the cerebral venous circulation, because of their relative infrequency have not received the concentrated attention of clinical investigators. Even so most of the literature concerned with the cerebral venous system is largely based on the great venous channels, the cavernous, superior sagittal, lateral and straight sinuses, while the changes incident to interruption of the cerebral veins have received scant mention. There has been a tendency to treat the cerebral veins as more or less useless structures devoid of physiological importance.<sup>1</sup> In the meager reports there have been few clinical descriptions of the motor and sensory changes to be expected from obstruction of the cerebral veins, of a nature sufficiently definitive so that the diagnosis of such occlusions can be made with the same confident certainty manifested in evaluating arterial lesions.

However, there has been slowly accumulating information with respect to the physical symptoms resulting from interruption of the drainage of the rolandic vein, so that the suspicion of such interference can be entertained with increasing confidence. The ideal basic situation for such a suspicion occurs when a prior disease exists in or near the superior sagittal sinus, such

as infection, a tumor involving or adjacent to the sinus, or trauma to the sinus. This paper is concerned with a further elaboration of the syndrome of the rolandic vein.

### LITERATURE

The present concept of the physical characteristics of a hemiplegia induced by obstructing the drainage of the superior cerebral veins was first postulated by Holmes and Sargent.<sup>2</sup> Their conclusions were based on a war experience with over seventy cases of traumatic damage to the sagittal sinus, injury to which produced a flooding in the drainage area of the rolandic veins. The clinical signs observed by them were described as a hemiplegia most marked in the lower extremity, frequently sparing the hand and face, with early muscular rigidity singular in quality and sensory disturbances of the gnostic type.

Previously Gowers,<sup>3</sup> in 1888, suggested that a hemiplegia observed under certain conditions could well have been produced by a thrombosis of the cortical veins, and noted that such hemiplegias were observed in patients dying of tubercular meningitis in whom thrombosis of the contralateral cerebral veins was found. Still earlier\* Dusch,<sup>4</sup> in 1861, without attempting to correlate the clinical and pathological

\* I am indebted to Orthello Langworthy for this reference.

\* From the Department of Neurology, New York University College of Medicine, the Neurological Unit of the Brooklyn Hospital, and the Neurological Service of Kings County Hospital.

observations, depicted similarly thrombosed cerebral veins in a hemiplegic woman who died from postpartum septicemia. Wimmer<sup>5</sup> noted right-sided focal signs in a patient in whom at postmortem examination an extension was found of a thrombosis of the superior longitudinal sinus into the left superior cerebral veins. Lannois<sup>6</sup> described a syndrome of ascending hemiplegia, characterized by hemiparesis and disturbances of gnostic sensibilities which he attributed to thrombophlebitis of the superior sagittal sinus. Chaliere and Nausac<sup>7</sup> reported the development of a terminal left hemiplegia and left-sided convulsions in a child who finally succumbed to a series of acute illnesses, the final phase being related apparently to a discharging right ear, without associated chills or fever. At postmortem examination there was thrombotic involvement of the superior longitudinal sinus with extension into the tributary superior cerebral veins particularly on the right.

Clear cut involvement of the cerebral veins without implication of the sagittal sinus in cases in which a contralateral hemiplegia was observed was noted by Davis,<sup>8</sup> Waggoner,<sup>9</sup> and Dowman.<sup>10</sup> In Davis' case extensive thrombosis of the left rolandic vein and its branches was found at operation and at necropsy in a patient who presented a right-sided hemiplegia with astereognosis in the right hand and hypesthesia. In Waggoner's case at postmortem examination extensive thrombosis of the left rolandic vein was disclosed. This patient developed a right hemiplegia sudden in onset. No convulsive attack or loss of consciousness occurred. There was no facial paralysis, no loss of speech and no loss of sphincteric control. The right leg was paralyzed and weak. Mild right-sided pyramidal signs were observed. Astereognosis was found in the right hand without loss of tactile pain or temperature sensibilities. Gradually, power returned to the right upper limb but he remained unable to use the right lower extremity.

In Dowman's patient, who recovered at

operation, the right rolandic vein was found to be large, bluish-black with compensating dilatation of neighboring veins, and with an excessive amount of fluid in the sulci. This patient complained of a gradually developing numbness over the left half of the body beginning in the face and slowly involving the left leg. The left hand was awkward. There developed weakness of the left hand and forearm. Loss of joint sense in the left fingers and of position sense in the left lower limb, with an exaggeration of the deep reflexes on the left were found. Dowman also noted the occurrence of a left hemiparesis after ligation of the right rolandic vein in the course of a transcortical approach to the third ventricle.

Recently three cases of "venous hemiplegia" developing after surgical interference with the superior cerebral veins adjacent to the sinus were reported.<sup>11</sup> These cases briefly abstracted are as follows:

#### CASE REPORTS

**CASE 1.** In a left-handed female, aged fifty, who had normal preoperative physical findings and who suffered from convulsive seizures of two years' duration, a parasagittal meningioma was removed from the left posterior parietal area. The tumor was easily accessible and was removed with minimal trauma to the adjacent cortex and without interfering with the arterial supply. It was necessary to occlude several large veins adjacent to the tumor and emptying into the sagittal sinus.

On the same day following the operation there was a flaccid paralysis of the right arm and leg. No facial paralysis or disturbance of speech were noted. The following day movements of the fingers of the right hand occurred. The third day a good grip in the right hand with slight movements at the right elbow were found. Astereognosis was noted in the right hand. There was "plastic hypertonicity" in the right upper extremity when moved passively. On the eighth day weak movements returned to the right shoulder and hip. Appreciation of vibration and the two-point test was impaired in the right hand. Muscle, joint and tendon sense was disturbed in the right toes. Pain sensibility was slightly diminished. By the twenty-fifth day there was a complete return of motor func-



tion except for diminution of movements of the right toes.

CASE II. A female, aged fifty-four, with a story of convulsive seizures for ten years, and dragging of the right leg for ten years, developed a right hemiparesis characterized by preservation of finger movements and grip, and absence of movements at the right elbow, shoulder and lower extremity. Marked plastic hypertonicity of the right extremities was observed. On the right there was found a mild sensory diminution to all modalities of sensation but chiefly the discriminative types. There was no facial paralysis and no defect in speech, despite a story of obvious right-handedness. A preoperative diagnosis was made of a left parasagittal meningioma and venous thrombosis of the cerebral veins was confirmed. A complete right hemiplegia except for face and speech was noted after operation. There occurred a progressive recovery of motor function following the cellular pattern of the rolandic strip.

CASE III. A woman of sixty-two presented clinical signs of a "sensory hemiplegia" of progressive development. Motor power was excellent and there were no clinical signs of intracranial hypertension. Diagnostic air studies indicated a neoplasm in the posterior aspect of the right cerebrum. Following operation a left-sided motor paralysis was found. The fashion of recovery again followed the motor pattern of the rolandic strip, beginning in the fingers and hand, and spreading in sequence to the elbow, shoulder and down the leg. The foot improved last.

Two cases with hemiplegia were recently described by Symonds<sup>12</sup> in which the major paralysis first occurred in the lower extremity. These were two of five cases presented as examples of cerebral thrombophlebitis. The first of the two cases was characterized by paralysis of the foot, weakness of the knee and hip, and slight weakness of the left upper limb. The patient recovered. Symonds made the following comment: "The distribution of the paralysis, leg affected severely, arm slightly, and face not at all, is what might be expected when thrombosis spreads from the superior longitudinal sinus into a tributary vein." The second case occurred in a woman who presented six transient

attacks of weakness of the right lower limb followed the next day by a slowly developing paralysis of the right side, beginning first in the foot, and later involving the upper limb. Convulsions occurred and five days later temporary right-sided weakness developed. The patient ultimately recovered. The following comment was made: "The lower limb was first affected—a right hemiparesis spared the face, palate, tongue and speech."

Recently Merwarth and Gold<sup>13</sup> reported an unconfirmed case in which were found all the clinical findings noted in the earlier cited cases. Three additional cases are presented in which following the surgical removal of a parasagittal tumor, the syndrome of a venous hemiplegia developed:

CASE IV. L. M., a thirty-six-year old female, was admitted to the Long Island College Hospital August 17, 1936, with the following story: Ten weeks previously she was awakened at night by jerking movements first noticed in the toes of the left foot which turned down. This was promptly followed by an involuntary straightening out of the left lower extremity, and an extension of the jerking movements throughout the left side of the body to the left upper extremity and the left side of the face. There was no loss of consciousness in the attack but she complained of an agonizing pain throughout the left side. This fit lasted fifteen minutes. The spells recurred frequently but the later attacks, although they still occurred nightly, involved only the left lower extremity.

Six weeks before admission the fit, which began as usual in the left foot, was followed for the first time by loss of consciousness. Just prior to losing consciousness, her face felt drawn to the left and she noticed buzzing in the left ear. On recovering from this unconscious spell she complained, again for the first time, of a headache over the top of her head. Since then daily headaches occurred up to one week prior to admission when there was a second severe convulsive attack with loss of consciousness, following which she appeared dazed, and complained of a feeling of heaviness and weight on the left side and numbness in the left foot.

The neural examination showed the following positive findings: There was an ataxia in the finger to nose and heel to knee tests on the left;

an increase of the deep reflexes in the left lower extremity with an extensor toe sign of Babinski, and poor postural sense in the left great toe. Early choking of the optic discs was observed.



FIG. 1. Case 1. Lateral view showing location of area of calcification.

On August 18, an x-ray examination of the skull revealed the following: "In the right upper mid parietal region there is a moderately large, irregular calcific opacity measuring  $2 \times 2$  cm., definitely within the brain substance particularly subcranial." (Fig. 1.)

*Operation on September 4.* "Upon opening the dura which presented no unusual findings, a parasagittal parietally situated tumor was disclosed. The tumor appeared to be a meningioma although it was quite soft on its periphery. It was not attached to the brain but had made a nest in the brain by external pressure. It was attached to the dura but did not implicate the longitudinal sinus. The rolandic vein traversed the thickened arachnoid across the most anterior except of the dura, at which point it was moderately constricted. After removal of the tumor the small dural attachment was cauterized with the coagulating current. An attempt was made to spare the entrance of the rolandic vein during this procedure. Complete hemostasis was accomplished." (Fig. 2.)

On the day following the operation, there was paralysis of the left side. She was not in shock and spoke intelligently. On September 7, she was mentally alert. There was no impairment of speech. On the left the deep reflexes were more active, and pathological superficial reflexes were obtained. Hypotonia of the muscles on the left was observed. There was a definite ability to

grasp with the fingers of the left hand in distinct contrast to the poor muscle power found throughout the remainder of the muscle groups on the left side.

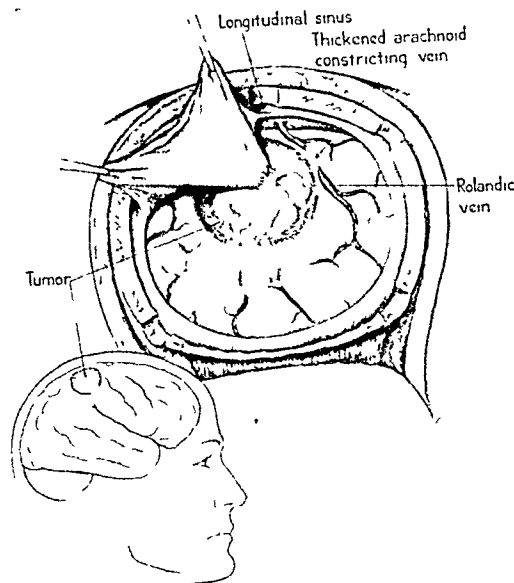


FIG. 2. Case 1. Relation of tumor and veins.

On September 10, a slight return of motion to the left upper extremity was observed. But on the following day the previously observed motions of the left upper extremity had disappeared. By September 13, movements had returned again to the left arm and fingers, and for the first time she was able to move the left leg. On September 16, very little residual paralysis on the left was noticed and four days later both upper extremities were moved without difficulty. By September 27, she was up and about the ward entirely free of complaints.

*Comment.* Although this patient presented a left hemiplegia immediately following the operation, she was alert. There was an initial return of function first in the fingers of the left hand, followed soon after in the elbow and shoulder.

There was a fluctuation in the return of function as shown by the disappearance of motor power in the entire upper limb for a brief period followed by a later complete return of power. The lower limb was the last to recover. There was no facial paralysis. The tone of the musculature was reported as hypotonic. The removal of the tumor presented no particular surgical difficulties except for the efforts made to

spare the rolandic vein skirting the anterior margin of the tumor.

The extent of the paralysis and the nature of recovery are quite characteristic of a venous hemiplegia. It seems logical that there was temporary interference with the drainage of the rolandic vein.

CASE V. H. O., a female, age fifty-one, was admitted to the Neurological Unit of The Brooklyn Hospital on April 8, 1940. Her general health was excellent up to two years previous when a convulsive spasm occurred in the left lower extremity. The left leg first felt tight and painful, and in a few minutes repeated jerking movements occurred lasting fifteen minutes. After this attack the entire left lower extremity became numb and remained completely paralyzed for one-half hour, slowly returning to a normal state one hour later. Six months later a second attack was experienced, and since then the convulsive attacks have gradually increased in frequency averaging three daily for the past two months.

During the past twelve months the patient complained of a constricting feeling about the temples. Very recently a weakness of the left leg in walking was noticed. Following diagnostic encephalographic air studies performed six weeks ago she was confined to bed. A depression of the body of the right lateral ventricle in the second and third portions, without a shift of the ventricular system, was found in the encephalogram.

Physical examination revealed the patient to be jolly, alert and oriented. There was mild bilateral papilledema of the optic fundi. No facial paralysis or weakness of the left upper extremity was found. Downward drifting of the extended left lower extremity and terminal tremor of the left hand in the finger to nose test was found. In all other neural tests the physical examination was normal.

On April 10, an operation was performed. A firm encapsulated tumor was found the size of a lime at the motor strip, along the longitudinal sinus, extending about 3 cm. along the convexity of the hemisphere. A large vein in intimate contact with the tumor and emptying into the sagittal sinus was divided in order to remove the tumor. Just posterior to the tumor a large vein, three times the size of the preceding vein was seen. The tumor possessed a rich parasitic vascular supply and was easily stripped from its

bed in the cortex, which showed little tendency to expand following removal of the tumor.

That same day at 11 P.M., a mild weakness of the left shoulder, elbow, left ankle and toes was noted. There was no facial paralysis. The left knee and ankle jerks were increased. Babinski's toe sign was obtained on the left.

On April 11, she was well oriented and alert. In the left hand the grip was good but skilled acts were impaired. The movements of the left elbow and shoulder were weak. The motions at the left hip and knee were performed weakly. There was no movement at the left ankle or toes. Appreciation of movement of the toes and fingers on the left side was grossly impaired, but that of pin prick was undisturbed.

On April 14, the patient was alert and cheerful. However, the entire left side was weaker. There was no motion of the left hand, foot or toes. All tests of sensation were normal. The following day the left grip was excellent and the left hand moved well. The left arm could be raised. No motion took place at the left ankle or toes. There was no increase of muscle tone.

The patient felt fine on April 17. A pillow could be moved with the left arm. The left foot could be pressed down but not up. On April 23, power throughout the left side was good save in the left ankle and toes, where only slight plantar flexion could be done. Skilled acts were not performed as well with the left as the right hand. The tone of the muscles on the left was not increased.

Eight days later, May 1, the physical examination was normal except for slight awkwardness in tests of skilled movements in the left upper extremity, and absence of movement about the left ankle save for slight plantar flexion.

*Comment.* Preoperatively there was found a minimum of abnormal physical findings, just a slight weakness of the left lower extremity and a slight awkwardness in the left hand.

At operation, the tumor was removed without difficulty. The vein intimately incorporated with the tumor was not cauterized but deliberately ligated. There was no use of electrocauterization except at the sinus edge of the tumor, where the adjacent dural margin was thoroughly cauterized. There was no disturbance with

the cerebral arterial circulation except for a minute arterial twig on the mesial aspect of the hemisphere. The surgeon, aware of

attack beginning in the left foot and then spreading to the left arm with his head turned to the left. There was no loss of consciousness

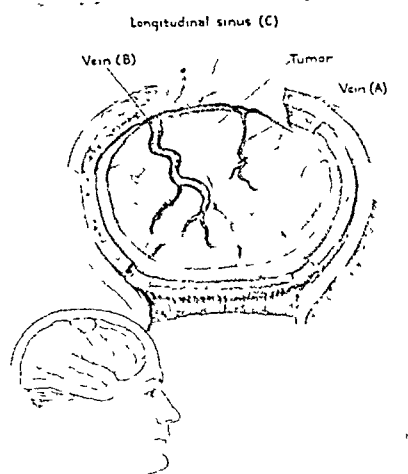


FIG. 3. Case II. Condition of veins noted at time of operation.

the possibility of a subsequent venous stasis, deliberately tried to avoid its production.

Nevertheless, at 11 P.M., the day of operation, the patient showed a paresis of the left side with sparing of the left hand and face.

Prior to discharge the patient recovered entirely except for movements in the foot, which evidences slight weakness prior to operation.

The severe paralysis of the foot may have been caused by the occlusion of vein draining the mesial aspect of the hemisphere as the alleged anatomic location of the foot is said to dip over into the superior mesial aspect of the hemisphere.

CASE VI. C. M., a colored male, of forty years, a former professional boxer was admitted to the Kings County Hospital, on September 8, 1940, because of convulsive episodes and a left-sided weakness. The past history was of no importance except for an injury to his head in 1928, at which time he was held up and severely slugged on the head. He was badly stunned but did not lose consciousness. At one time he received a series of injections in the arm for reasons unknown to him. In 1934, he first became aware of a "lump" in the midline of his head.

In 1937, he had had his first convulsion, the

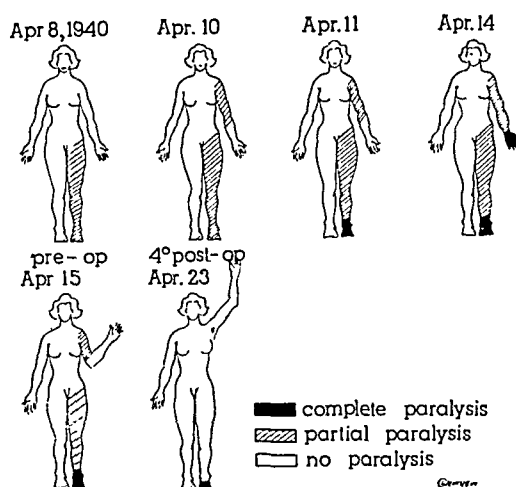


FIG. 4. Case II. Showing progress of recovery.

for the attack happen at night and wakened him. In the beginning the attacks occurred about once every two months, gradually increased in frequency so that he required care in many hospitals. On July 4, 1938, after an attack, the left side remained paralyzed for four days and then gradually improved but always remained somewhat weak thereafter.

The physical examination on admission was as follows: The patient was mentally clear but somewhat unstable emotionally. His speech was slow and deliberate. He was right-handed. There was a dome-shaped bony prominence (7 cm. in length) in the anterior right parietal region. The optic discs were flat. There was a definite but slight, left hemiparesis most marked in the left lower extremity especially in the foot which dragged in walking; a lessened arm swing to the left extremity; slight clumsiness in the left hand, and a left facial flattening.

Conclusive evidence was found in the x-ray examination of a hyperostosing meningioma. (Fig. 5.) On October 8, 1940, an operation was performed, and a large tumor was found at least 6 cm. in length involving the longitudinal sinus and extending on both sides of the sinus, one-fourth of the amount on the left and three-fourths on the right. The tumor derived its greatest blood supply from the falx and the sagittal sinus, the large surface vessels being displaced. To remove the tumor complete resection of the superior sagittal sinus invaded by the tumor was done both anterior and posterior to the growth. (Fig. 6.)

*Postoperative Course.* On October 9, at 9 A.M. the patient was readily aroused and answered questions. No demonstrable aphasic

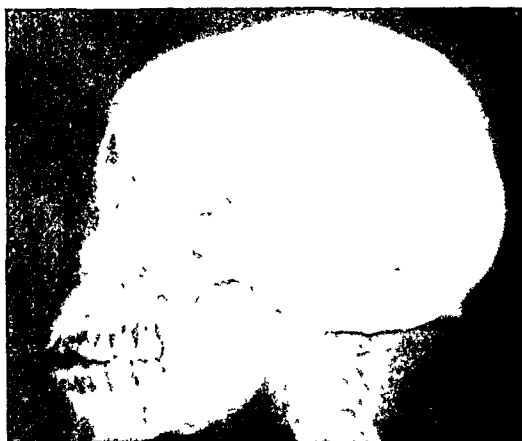


FIG. 5. Case III. X-ray showing area of hyperostosis in the midline of vertex.

were stronger although fluctuations in power still were observed. The nurse noticed movements at the right thigh for the first time. By



FIG. 6. X-ray to show the amount of sinus removed. The most anteriorly and posteriorly placed clips indicate the segment of sagittal sinus resected.

disorders were present. There was a complete paralysis of the left upper and both lower extremities. Both knee jerks were obtained. Pin prick seemed to be well appreciated. At 5 P.M. the grip was present in the left hand. The biceps jerks were brisk. Movements of the toes were not appreciated in the left foot. At 9 P.M. the whole left upper extremity was not flaccid and paralyzed. A grasp reflex was found in the right hand.

October 11, at 11:45 there were distinct, free, strong finger movements of the left hand with total absence of movement at the left elbow and shoulder. Plastic hypertonicity was found throughout the left upper extremity, considerable force being required to move the arm at the elbow. The movements of the left fingers were well appreciated. The deep reflexes were hyperactive, the left more so, in the lower extremities. At 12 o'clock, fifteen minutes later, the above movements noted in the left fingers had disappeared. This striking variation from return of finger movements to paralysis had been observed on four previous occasions. The patient became aware of the interest in the progress of the return of function and informed us of any change.

On October 14, movement at the elbow was first observed and the finger movements were present more constantly.

The following day slight movements were present at the left shoulder, the patient being able to raise the left upper extremity. The left grip was excellent. At the elbow the movements

October 23, there was complete recovery in the left upper extremity and definite flexion of the left thigh.

On November 6, strong movements were present in the right thigh and slight movement at the right knee. By November 9, increased power at the right hip and knee and slight movement of flexion at the left hip. The patient became aware of a change before any perceptible movement occurred as the dead or numb sensation disappeared, for he remarked that he had a "return of feeling" in the right lower extremity before he could move it and now was beginning to have feeling at the left hip.

The nurse in charge observed the same ebb and flow in the return of motor power at the hip as was noted in the left fingers.

On December 11, there was free movement of the right lower extremity except at the ankle, and also at the left hip. Slight movement was observed at the left knee. Because of a continuing drain of serous discharge from the anterior margin of the flap the inserted protective rubber drain was removed. The underlying cortex was found covered with a heavy, creamy white exudate.

On December 15, the patient was able to stand although no movements at the ankles were possible. He was bright and alert.

On January 6, 1941, encephalographic air studies were performed which showed normal

position of the ventricles. The general condition of the patient was fair. There were 750 cells in the cerebrospinal fluid. The patient died on January 15, of bronchopneumonia.

**Postmortem Examination—Gross Examination.** The brain was removed with the dural membranes intact. Over the area of brain previously covered by the protective rubber drain there was a mucinoid exudate, judged to be reactive.

On reflecting the dura forward (Fig. 10) a small area of underlying cortex pulled away with it (shown as a light island about the center of the reflected dura). The previously depressed cortex, formerly the nest of the dura, had expanded to form a fairly even surface. The sinus both anterior and posterior to the resected segment was found patent. (Sections were removed for microscopic analysis.)

The cerebral veins on the superior aspect of both hemispheres were not distended. There were no gross superficial hemorrhages observed over the cortex.

Coronall sections (1 cm. in thickness) showed mild ventricular dilatation. On the right the superior portion of the ventricle was pulled by apparent cortical shrinking occurring about  $1\frac{1}{2}$  cm. from the middle cerebral fissure. The cortex on the right and slightly on the left at a point corresponding to the left-foot area (motor and sensory) showed small areas of necrosis. The remainder of the cortex corresponding to the upper limb and face was normal.

Sections of the sinus removed for microscopic examination were entirely normal.

**Comment.** The failure of the recovery of movements in the lower limbs, the foot movements on the right, and knee and foot movements on the left, at least up to the time of death, is perhaps explained by the gross changes observed in the cortex.

The paralysis was immediate and fully developed at the time the patient was first observed shortly after the operation. Because of experiences obtained in other cases in which there had been interference with rolandic venous drainage, unusually careful scrutiny was applied to this patient.

The degree of paralysis, two lower limbs and the left upper limb, resembles the severe palsies noted in acute injury to the

sagittal sinus. The pattern of motor recovery parallels the fashion observed in the hemiplegic cases. It was in this patient that

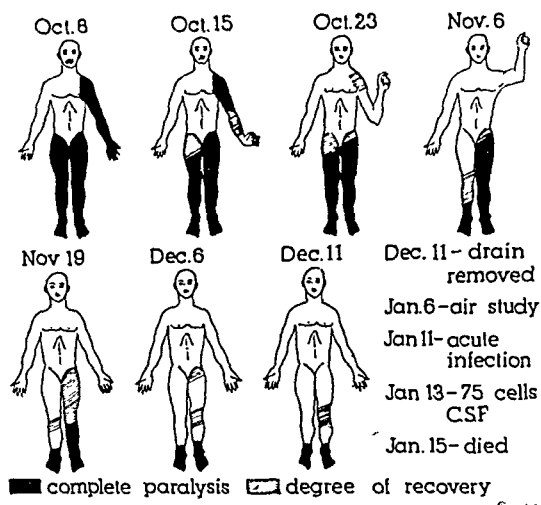


FIG. 7. Case III. Showing the pattern of motor recovery.

the tendency to variation in motor power stood out prominently, particularly in the left upper limb, finger movements being found at one examination and one-half hour later seen to be absent. Also the fluctuation in the state of muscle tone was conspicuous, being flaccid at one observation and extremely spastic at another. This feature was especially marked in the arms but was not so obvious in the lower limbs. It is noteworthy that urinary control was present immediately following the operation. The mental state was clear except for the last two days, preceding his unfortunate death from pneumonia.

#### DISCUSSION

As previously stated the modern concept of the total picture resulting from interference with the drainage of the superior cerebral veins dates from the aforementioned publication of Holmes and Sargent.<sup>2</sup> Unfortunately, their work is quoted only when references are made to abnormal states (trauma and inflammation) involving the superior longitudinal sinus itself. These authors state unequivocally that the clinical manifestations are caused by changes in the cortical veins, although the basic primary damage in many cases was

to the sagittal sinus in the neighborhood of the parietal lacunae, the point of entrance of the rolandic vein. This paper is so

limbs were found rigid in flexion, but as a rule it was so great that the limbs could not be passively flexed or separated from one another



FIG. 8. Case III. Showing the practically completely occluded sinus (arrows point to sinus).

FIG. 9. Case III. Showing the organization within the sinus.

significant that a complete transcription of a typical case reported by them is in order:

**CASE VII.** Private J. H. was wounded by a bullet on December 1, 1914. He became unconscious at once, and was unable, on admission to the base hospital two days later, to give any accurate information about himself. He was dull and apathetic but answered questions quite readily.

There were two separate penetrating wounds, 4 cm. apart, and equidistant from the midline, about 17 cm. behind the nasion—that is, slightly behind the midpoint. The entrance was on the left and the exit on the right, slightly larger and slightly anterior to it; the skull between them was comminuted.

His speech and the functions of all his cranial nerves were unaffected, but the retinal veins were swollen and the inner margins of the optic discs were blurred and indistinct.

His arms lay adducted to his side, flexed and pronated at the elbows, and were very rigid at the shoulders and elbows, but only slightly so at the wrist and in the fingers. He was unable to perform any voluntary movement with the right, but could flex and extend the left fingers feebly. The abdominal muscles were rigidly contracted and respiration was mainly thoracic.

Both lower limbs were very rigid and fully extended at hips, knees, and ankles, and rotated inward and adducted at the hips, so that the patellae came in contact with one another; owing to their position and their extreme rigidity they resembled strongly the lower limbs of a severe case of Little's disease. This extensor rigidity was not constant, as occasionally the

by any reasonable force. The knee and ankle jerks were much exaggerated and the hamstring jerks were present and brisk; the flexor jerks in the arms were also exaggerated, but the triceps jerks were feeble; both plantar responses were extensor and the abdominal reflexes were absent. When admitted his mental state was too dull to permit a proper examination of sensation.

Three days later he had a prolonged left-sided Jacksonian fit which commenced in the face. Ten days after receiving the wound he showed definite signs of improvement; his lower limbs were still completely paralysed and extremely rigid, fully extended, adducted and rotated inward, but he was now able to move his fingers freely, and perform feeble movements at the elbows; his shoulders were, however, still rigid and their movements paralysed.

Twelve days later all movements of the upper limbs were possible, but the proximal muscles, especially of the right, were very feeble and all efforts he made were very ataxic; both arms were still rigid at the shoulders and the right at the elbow, and constantly lay closely adducted to the sides and flexed.

The legs, too, remained extremely rigid, extended, adducted, and rotated inward, but he occasionally had strong flexor spasms in them, especially when turned on his side. No definite voluntary movement of either was possible, and any effort only resulted in a general contraction of all their muscles, and a slow vigorous extension if any segment of the limbs were flexed. Stimulation of either sole produced a vigorous withdrawal movement of the limb without any contralateral effect.

All the tendon jerks were greatly exaggerated, the plantar responses were of the Babinski

type, and the abdominal reflexes were abolished.

The examination of sensation revealed, especially on the right side, the disturbances found in pure cortical lesions when the stage of shock or diaschisis has passed; the lightest touches could be appreciated normally, but a certain percentage of purely tactile contacts failed to evoke a response, and this failure bore no definite relation to the intensity of the stimulus. Localization of touch stimuli was, however, not seriously disturbed. There was no diminution to painful stimuli, and no definite subjective difference in pinpricks between normal and possibly affected parts. The appreciation of position and of passive movement was almost completely lost in both lower limbs and in the right arm, but was little affected in the left arm; and corresponding thereto the discrimination of Weber's compass points was much disturbed in the legs and in the right arm; the two points could be distinguished 1 cm. apart on the left palm, while on the right they could not be recognized at double this distance, or on the soles when separated to 10 cm.

During the time he remained in the base hospital he had slight difficulty in passing urine, and occasionally incontinence; this he explained as due to the fact that he could "only hold his water for five minutes or so," and that it then passed involuntarily if he did not receive a urinal.

He was evacuated to England five weeks after receiving the wound, and had gradually improved during this time. His subsequent history is not known at present.

#### ANATOMY

The syndrome under discussion is concerned with the venous drainage on the lateral superior surface of the hemisphere, chiefly the veins emptying into the parietal lacuna, the rolandic veins. Since the complete picture is dependent upon the unusual characteristic of the physical set up of the somatic representation in the rolandic motor strip and the mode of drainage, a brief consideration of the pertinent anatomy is warranted.

The superior longitudinal or sagittal sinus is roughly short of a foot in length, and commences at the foramen cecum

through which it receives a vein from the nasal cavity. It runs from before backward in an arching fashion to the torcular Hero-

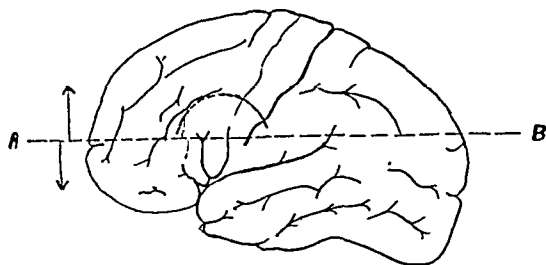


FIG. 10. Rough sketch to show approximate area of external brain surface drainage by the superior cerebral veins above line A-B, and the sylvian system below line A-B. Arrows indicate direction of venous current in relation to line A-B, drawn through tip of sylvian fissure.

phili where the main channel deviates to one side, usually the right, and is continued as the lateral sinus. On its inner surface are the openings of the superior cerebral veins. Into this sinus empty the superior cerebral veins, which, while not following a strictly constant pattern, usually unite into four principal trunks: (1) frontal (2) precentral, (3) postcentral or rolandic and (4) an occipital. Of these the postcentral or rolandic vein is usually the largest and as it drains the pre- and postcentral gyri are the most important. On the mesial aspect of the hemisphere are corresponding veins which empty into the sagittal sinus approximately at the same point as the neighboring veins on the lateral hemispherical surface. The veins empty into the sinus at a gradually increasing obliquity, the foremost group at right angles while the posterior group enters at a sharp forwardly directed angle. Over the occipital lobe there may be no veins entering the sinus.

The lower half of the lateral surface of each cerebral hemisphere is drained by the sylvian vein, which drains the face, hand area, as well as the temporal lobe, and empties into the cavernous sinus. An important anastomotic connection unites the superior and inferior groups, the so-called anastomotic vein of Trolard. In addition a further anastomotic reserve is found in the vein of Labbe which unites the sylvian vein



with the superior petrosal sinus at the point where it joins the lateral sinus.

An important anatomic variation in the cerebral veins as contrasted with the systemic veins is the complete absence of valves which readily permit the rapid shunting of blood.

The cerebral veins are fine, soft, easily compressible and enter directly into the hard, thick, resistant dural sinuses.

There exists a vast anastomosis between all of the veins in the superior cerebral surface, forming a great network over the cortical surface.

The flow in the systems is in opposing directions. In the erect posture the flow in the superior cerebral veins is upward to the sagittal sinus, while in the inferior group it is downward toward the cavernous sinus. Because of their anatomic position the flow in the posterior groups of superior cerebral veins is against the current in the sagittal sinus which normally flows backward to the torcular Herophili.

The veins draining the rolandic area, both the pre- and postrolandic terrain, are the particular veins under consideration in this presentation. It is the interference with the circulation in these veins which produces the characteristic syndrome. According to Holmes and Sargent, the area on both sides of the rolandic fissure, above a horizontal line drawn through the tip of the sylvian fissure represents the drainage area of the rolandic veins.

The parts drained from above along the interhemispherical fissure down to the sylvian fissure follow the classical representation of the cellular pattern in the rolandic strip. According to this concept the motor areas representing the face, tongue and speech are spared. Also the motor area representing the hand may be spared or slightly involved.

The pressure in the cerebral venous system is low, the flow being largely maintained by arterial pulsations. The current is easily influenced by such normal activities as coughing, sneezing, straining at lifting or at stool. Ordinarily, these acts are

without harmful effect because the absence of valves in the veins favors a reversal of flow of the sluggish venous currents. Because of the naturally elaborate interlinking, the tendency to reversibility is protective in that minor checks of the normal flow in one area are readily compensated for by the ease with which the flow is directed elsewhere.

The elaborate anastomotic capacity, the absence of valves, the easy reversibility of current flow, serve to function as a great absorbing sponge when required. On the other hand, the angle at which the posteriorly placed superior cerebral veins enter the sinus, the flow in them being opposed to the current in the sinus, the fine, small caliber of the veins, the low venous pressure leading to easy compressibility are conducive to the production of serious changes once a noxious agent is introduced.

The freedom of anastomosis undoubtedly serves as a sponge to counteract a block at any point in the system. The efficacy of the well knitted collateral circulation determines the response to an occlusion. An interference with drainage in the superior veins, as they are about to enter the sagittal sinus, is immediately reflected in the surrounding web-like venous channels, which if adequate, as is probably very often the case, may result in an asymptomatic occlusion. When a stasis occurs, it is reflected by a damming up into the most minute venous pathways. The cortical gray matter and underlying white matter are affected. The function of the cortical cells is disturbed, producing both prerolandic and postrolandic signs and symptoms.

Temporarily, there may be an overflow into the sylvian system affecting the hand, accounting for an early paralysis of the hand, which rapidly recovers its functions as soon as the sylvian system can carry the extra burden. The functions of the elbow, shoulder, trunk, hip, arm and leg are lost, recovering in this order. The essentially gnostic sensory disturbances which are found are attributed to the same interference with venous flow in the cerebral veins.

## PATHOLOGY

The pathological changes observed in fatal cases have been well described by Holmes and Sargent:<sup>2</sup> "When the dura mater was removed the most striking feature was the condition of those superficial cortical veins which enter the sinus at the position of the wound; these were swollen, firm to touch, and could not be emptied by pressure, and there frequently seemed to be congestion of the neighbouring veins which were not actually thrombosed. The superior parts of the hemispheres which were drained by these veins were usually swollen and their convolutions flattened by pressure against the inner surface of the skull, and generally firm to the touch. On section there was obviously much oedema of the cortex and subcortical white matter, and minute hemorrhages, which were grouped more closely in the neighbourhood of the wound, were found. In a few instances there was an actual softening near the mesial fissure, the disintegrated brain matter being blood-stained, and punctiform hemorrhages were found in the cerebral tissue around it."

Evidence of previous bleeding or fresh bleeding in the cerebrospinal fluid is not an unusual finding in proved acute interruption of the venous circulation in the longitudinal sinus or in its tributary veins. Holmes and Sargent noted that "In a few of the cases which came to postmortem examination and in others in which the condition could be observed during operation, there were widespread subdural hemorrhages, which usually formed a thin layer of blood over the convexity, and sometimes extended to the base of the same hemisphere; in other cases cerebrospinal fluid removed by lumbar puncture was either blood-stained or straw-coloured." Dusch<sup>4</sup> (1861) quoted a case of thrombosis of the longitudinal sinus which at autopsy revealed changes in the sinus, and reported that "the whole of the pia mater on the surface of the brain and between its convolutions is replete with blood, and in some

places, especially on the right sylvian fissure, more considerable extravasations exist." Irish<sup>14</sup> (1938) likewise noted extensive subarachnoid bleeding in one instance of cerebral venous thrombosis. Large subarachnoid hemorrhages and hemorrhagic foci of necrosis in the cerebrum were almost invariably accompanied by thrombosed veins in the observations of Byers and Hass<sup>15</sup> (1933).

SURGICAL SECTION OF THE  
SAGITTAL SINUS

In surgery the question arises as to the advisability of resecting a segment of the sinus whenever it is directly involved by tumor, such as the meningiomas which are prone to recur unless the primary focus is completely removed. While it is true that sudden obstruction of the circulation within a previously unoccluded sinus provokes serious sequelae, changes of equally severe degree result from accidental trauma to the rolandic vein alone. Unfortunately, all previous emphasis has been on damage to the sinus, the important tributary veins having been seemingly ignored. Surgeons have long been aware of the danger in tampering with a patent sinus, so much so that there are few recorded accounts of deliberate sinus resection. In the available reports there is little mention of the state of the tributary veins or the number of veins ligated, except for the descriptions noted in Dandy's recent paper. Apparently, the first reported planned attack on the sinus occurred in 1911 when Kenyon<sup>16</sup> placed ligatures about the sinus  $2\frac{1}{2}$  inches apart. The entire problem of the attack on the sinus was considered in detail by Cushing,<sup>17</sup> Adson,<sup>18</sup> and more recently by Dandy.<sup>19</sup>

The writer has been able to collect a total of thirty-one cases (Table 1) from the literature and from personal communications received from neurosurgeons. Where the sinus was removed anterior to the rolandic point (seventeen cases) there were six cases in which no postoperative disability was noted (Dandy's two cases, and one each of Adson and Sheldon,<sup>20</sup> Grant,<sup>21</sup> Vincent,<sup>22</sup>

TABLE I

No	Year	Surgeon	Reason for Resection	Location	Amount of Sinus Resection	Operation	Immediate Sequelae	End Result	Condition of Resected Sinus
1	1911	Kenyon (Rep 1915)	Parasagittal meningioma	Anterior $\frac{1}{2}$	Ligatures $2\frac{1}{2}$ inches apart	Ligation			
2	1922	Rand	Parasagittal meningioma	Anterior $\frac{1}{2}$	10 cm	Second operation	None	Lived 18 years	
3	1923	Horsley quoted by Penfield	Bilateral—parasagittal meningioma	Frontal		At second operation	Died		
4	1923	Towne	Hyperostotic meningioma	Anterior $\frac{1}{4}$	8 cm		None	Died 2 months	
5	1928	Grant (Rep 1933)	Bilateral—hyperostotic meningioma	Frontal	4 cm		None	Recurrence	Sinus occluded
6	1933	Ira Cohen	Bilateral meningioma	Occipito-parietal	5 cm beginning 2.5 cm above torcular	First operation section of sinus, removal of tumor	Died same day		Sinus occluded
7	1934	Vincent reported by David et al	Parasagittal meningioma	Anterior to rolandic veins	5 to 6 cm	Tumor and sinus	None	Recurrence	Sinus occluded
8	1935	Tonniss	Meningioma	Torcular region		Removal of postag sinus, lateral sinus intact	None	Recurrence, homonymous hemianopia	
9	1937	Davidoff	Bilateral—hyperostotic meningioma	Extensive mid- and posterior portion of sinus			Mild hemiplegia	Recurrence	Sinus occluded
10	1938	Adson	Parasagittal meningioma	Anterior to Rolandic veins		Removal of tumor, section of sinus	None	Recurrence	Not determined
11	1939	Rowe	Parasagittal meningioma	Mid- and posterior portions	Extensive amount not mentioned	First operation, removal of tumor section sinus	None	Recurrence	Not determined
12	1939	Horrax Maltby	Parasagittal meningioma	Mid- and posterior portions	5 cm	First operation tumor and sinus	Left hemiplegia	Recurrence	Occluded
13	1939	Horrax Maltby	Parasagittal meningioma	Parieto-occipital	6 cm	First operation tumor and sinus	Left hemiplegia	Recurrence	Occluded
14	1928	Dandy	Parasagittal meningioma	Frontal	8 cm removed 4 cm ant to rolandic V	Third operation sinus removed	None	Died 3 mo of recurrences	Occluded
15	1936	Dandy	Bilateral parasagittal meningioma	Frontal	8 cm	First operation	Unsuccessful	Well (3-10-40) Recurrence	Occluded
16	1939	Dandy	Left parasagittal meningioma	Mid- and posterior portions	10 cm	Second operation	Paraplegia	Recurrence	Occluded
17	1940	Dandy	Bilateral—parasagittal meningioma	Mid- and posterior portions	6.5 cm extending backward	Third operation	None	Recurrence	Not determined
18	1937	Browder	Parasagittal meningioma	Anterior $\frac{1}{2}$		First operation	Hemiplegia	Left hem	Occluded
19	1940	Browder	Parasagittal meningioma	Anterior $\frac{1}{2}$		First operation	Hemiplegia	Recurrence	Occluded
20	1940	Browder (case III in paper)	Bilateral—parasagittal meningioma	Mid- and posterior portions	10 cm	Resection first operation	Cranial paraplegia and left arm	Recurrence except for left foot, died of pneumonia	Occluded
21	1940	Kaplan	Olfactory groove meningioma	Anterior $\frac{1}{2}$		First operation	?	Recurrence	Not occluded
22		J King	Metastatic carcinoma frontal pole	Extreme anterior portion	4 cm	Resection	None		
23		J King	Parasagittal meningioma	Premotor area	4 cm	Ligation of sinus to control bleeding	Left arm bad ? cause ? Brain tumor		
24		J King	Parasagittal meningioma	Anterior to rolandic vein	?	Resection	Motor weakness following operation		Not determined

TABLE II  
CUSHING'S SERIES

No.	Year	Type Tumor	Location and Amount Resected	Operation	Postoperative Complications	End Result
1	1913	Hyperosting 503-4	5 cm. right pariet-occipital	Attempted removal en bloc tumor, falx and sinus, 5 cm. sinus involved	Died	Died from ersan-quination
2	1924	Hyperosting 503-6 Bilateral	Frontal $\frac{1}{3}$	Radical incomplete removal tumor, falx, and sinus	Rhinorrhea	18 months
3	1925	Nonparasagittal 455-29	5 cm. ? central $\frac{1}{3}$	Fourth operation recurrence sinus, tumor and falx	Increase of hemiplegia; gradual recovery	1935—5th (Hor-rax) wheel chair; crural paraplegia
4	1927	Hyperosting 504-8	6 cm. paracentral	Partial removal of growth and sinus	Diplegia	Died three years; diplegia
5	1929	Bilateral 460-41	Frontal $\frac{1}{3}$	Extirpation of bi-lateral tumor with cyst, sinus and falx	.....	Died 1 mo. post-operatively; thrombosis femo-ral
6	1931	Bilateral 441-46 452	6 cm. central $\frac{1}{3}$	Recurrence excision bone, sinus and falx	Diplegia; slow re-covery	Self supporting 1937
7	1935	505-11 Horrax	8 cm. up to roland-ic veins	Recurrence of tu-mor and sinus	None	Good recovery 10 years

and Rand.<sup>23</sup> Portions of the sinus at or posterior to the rolandic point were removed by Tonniss,<sup>24</sup> Davidoff,<sup>25</sup> Rowe,<sup>26</sup> Maltby,<sup>27</sup> two cases, Dandy two cases, Browder\* one case, Cushing four cases. Of the latter group there were three cases (Rowe, Tonniss and Dandy) in which no new postoperative symptoms occurred. Rowe's case was entirely free of physical signs at all stages. Dandy's Case III was remarkable because of amount of sinus resected, 10 cm. of the mid- and posterior portions, and the number of veins occluded. "Several veins entering the sinus from the hemispheres were thrombosed with the electrocautery and divided. These veins included the rolandic veins on both sides. About eight veins were thrombosed on the two sides; all of them were very tortuous."

A most astounding case was reported by Davidoff<sup>25</sup> in which at three carefully con-

\* Personal communication.

sidered operative procedures one of the largest recorded occluding meningiomas was removed from the mid- and posterior parts of the sinus with a resulting temporary hemiplegia. In one of Maltby's cases, in which the sinus was removed at and posterior to the rolandic point, a postoperative hemiplegia occurred with ultimate recovery.

As far as could be determined from an analysis of Cushing's figures (Table II), he had occasion to resect the sinus in seven cases of tumorous invasion. The first occurred in 1913 when 5 cm. of the parieto-occipital portion of the sinus was resected with operative fatality. Three other deliberate resections in the area of the rolandic portion resulted in a recovered crural paraplegia in one case, a permanent crural paraplegia in a second, and a recovered hemiplegia in a third. Two frontal cases did poorly which is significant

in that this part of the sinus is mentioned as most favorable for attack. But one of the cases had no postoperative motor paralysis.

In all instances in which resection of the sinus was followed by recovery, a subsequent study of the resected sinus revealed complete occlusion. This suggests an occluding process acting over a long period of time, thus permitting the utilization of the profuse collateral circulation, already available. Dandy contends that "removal of a sinus, previously occluded by compression or direct invasion adds little or nothing to the demand for collateral venous circulation." However, this is true only if the established collateral circulation is sufficient for even when the sinus has been obstructed, unforeseen inadequate drainage patterns may still provoke disaster, as in Case iv in this report.

Cushing remarked that "when tumors involved the anterior third of the sinus a large section of it might be with safety excised along with the tumor mass." Even in this portion of the sinus handling is not unattended with danger, for two of Cushing's anteriorly placed cases did badly, and in Horsley's<sup>28</sup> case sepsis of the anterior portion of the sinus had eventually invaded a tributary cerebral vein with resulting hemorrhage into the brain tissue. Cushing believed that the after-effects of an acute surgical excision of the segment in the mid- and posterior portions would presumably be as serious as those produced by an acute thrombosis; and that the matter of dealing with an uninvolved sinus at the primary operation was still an open question. This question was debated when a patient had a parasagittal recurrence after fourteen years and following resection of 4 cm. of the sinus developed a permanent paraplegia.

The importance of the potential danger in suddenly interrupting the circulation in the posterior cerebral veins was also recognized by Elsberg<sup>29</sup> because of the possibility of inducing protracted plegias. In a personal communication, Stookey\* observed that only when the sinus is

occluded by tumor is it advisable to cut across the sinus. Neurosurgeons in general are unanimous concerning the dangers of cutting across a sinus not obstructed by a tumor either through compression or invasion.

Although the literature stresses the major emergent channel, the sagittal sinus, as the part to be treated carefully, precise consideration shows that it is the tributary cerebral veins which are of basic importance. In the reported cases of successful removal of a portion of the sagittal sinus behind its vulnerable site—the rolandic point—there ensued physical signs of varying severity with progressive recovery and in two instances no postoperative sequelae. Such favorable response indicates that a previous circulatory adaptation has been set up by means of the profuse venous anastomoses existing between the terminal cerebral veins and also their many interlocking tributaries. In such circumstances undoubtedly for a long period of time prior to operation the sinus could no longer have been used for the transmission of blood, which instead of flowing upward to the sagittal sinus, utilized the connections between the superior and inferior systems made possible by the anastomotic vein of Trolard. When physical symptoms occur after surgical interference with the sinus they are the result of the impact felt on the drainage area of the disturbed cerebral veins.

The conclusion may be drawn that occlusion of the sagittal sinus by tumor may be asymptomatic only provided the shutting off of the venous flow in the sinus is the result of a gradual occluding process acting over a long period of time, during which period other collateral venous channels are developed.

At the present time the possibility of determining whether satisfactory occlusion exists, or even so, whether there will or will not be unfortunate sequelae following removal of a portion of the sinus is totally unpredictable and is clearly in the lap of the gods. Dandy states "there is as yet no

\* Personal communication.

available evidence by which it can be known whether the longitudinal sinus can be removed in part before gradually progressive occlusion has occurred."

#### SYMPTOMS AND SIGNS

The symptoms and findings as revealed in these patients resemble closely those described by Holmes and Sargent. However, we have found that one of the outstanding features of a venous hemiplegia is that of symptomatic fluctuation, which, though it may have been observed, is not mentioned in their report. This embraces both the motor and sensory fields. It is this variation in clinical manifestation of a venous hemiplegia, especially early in the course of its development, which necessitates frequent examinations for otherwise the rapidly shifting picture may be missed.

The responses of the patient in the higher fields of intellect are relatively unimpaired. Despite the usual shock attending a major surgical procedure, the patient is surprisingly alert on recovering from an anesthetic. There is complete comprehension and every effort is made to co-operate with the examiner. Also, when the patient is seen before an operative procedure, the appearance does not suggest sickness. (The syndrome was observed in one patient prior to operation.)

This picture is in marked contrast to that presented by a patient suffering from a hemiplegia on an arterial basis. Such a patient, if conscious, is apprehensive. There may be cold, clammy perspiration. Also considerable confusion, cloudiness of consciousness, disorientation and urinary incontinence may be present.

The disturbance of speech, both aphasic and dysarthric, usually found in arterial disorders is totally absent. In three of the cases herein presented, the patients were right-handed, and the hemiplegia occurred on the left side so a possible disturbance of speech can not be evaluated. However, in two of the patients, whose cases were previously presented<sup>1</sup> the hemiplegia was

on the right side in right-handed individuals, and in neither case at any period either pre- or postoperatively was there a suggestion of aphasia. Holmes and Sargent observed this finding without exception in their large series. Such an observation is in great contrast to the common aphasic defects noted in the usual arterial lesions.

In the first two cases presented there was no facial paralysis noted before or after the operation. The third patient presented a left facial flattening prior to the operation but it was not increased by the surgical procedure even though there was a complete paralysis of the left upper and lower limbs. In arterial disease the facial paralysis is common, conspicuous and persistent.

The type of paralysis found is characteristic. The lower limb, particularly the foot, is paralyzed to the greatest degree. In the upper limb it is the proximal joints which are weakened while the finger and hand movements are usually preserved and if involved soon recover. This is in distinct contrast to the capsular hemiplegia in which movements of the upper limb, especially the fingers and hand, are absent.

Early in the disease the tone of the musculature on the paralyzed side is unusually spastic. Also there is marked fluctuation in the state of tonus, which as mentioned in the comment in Case III, varied in the course of several examinations. An extreme degree of rigidity requiring force to move the limb may be noted at one examination and subsequently the limb may be hypotonic. Naturally, this phase of the illness may be missed completely if frequent examinations are not made. The quality of the tone is best described as plastic during the state of rigidity, the limb becoming freely movable as motion is maintained at the joint tested. Invariably the state of tone in the arterial hemiplegias is hypotonic, during the first twelve days, and it is only as the plegia persists that the hypertonic state is found. Furthermore, in arterial lesions there is a tendency to fixation at the joints, quite in contrast to the venous hemiplegia.

The reflex state shows the same fluctuations. The deep reflexes are hyperactive early, although if examined during the state of "nonrigidity" they may be diminished. In arterial hemiplegia the deep reflexes are invariably absent in the early stages.

The recovery of motor function is the second outstanding feature of a venous hemiplegia. The pattern of recovery follows the outlined motor representation in the rolandic area. As stressed, the hand and finger movements may remain unimpaired but if implicated are the first to recover. The picture of preserved function in the fingers and hand with absence of movement at the elbow, shoulder, and lower limb is striking and impressive. In the course of time function returns progressively to the elbow, shoulder and lower limb. The last function to recover, if at all, is that of foot and toe movements; and the same quality of fluctuation in recovery of motor function is manifested. In all three cases the fluctuation from use to nonuse was manifested but was very marked in Case III. In the course of an hour's observation the power returned, disappeared, and returned again to the movements of the left hand and fingers. The same fluctuation occurred at the elbow and shoulder and again in the lower limb. Similar variation from paralysis to use and again recurrence of weakness was noted in a postpartum hemiplegia with recovery in which the cause was never determined. In one of Symonds' cases of cerebral thrombophlebitis this ebb and flow of power occurred at least six times in twenty-four hours before the actual paralysis developed.

It is noteworthy that preceding the recovery of motor function the patient is conscious of an improved sensation in the paralyzed limb. In Case III the comments of the patient were emphatic. In Dandy's third case of sinus resection the remark is made "on the day before motor function began to return he noticed increased feeling in both legs."

How different is the fashion of recovery in an arterial hemiplegia. The paralysis is

immediate and well established. The first function to return is that of the lower limb. Even when the patient becomes ambulatory, fairly complete paralysis of the upper limb may remain with an emphasis on the weakness of finger movements.

The sensory loss is chiefly in the gnostic field, postural appreciation, two-point test and object recognition. If pain sensibility is disturbed it is not marked. The recovery of gnostic sensory function does not parallel that of motor recovery, but remains somewhat delayed. In Case III in the presence of good motor power in the fingers there still was impairment of postural appreciation. The capacity to recognize objects, two-point test, and posture in the fingers returned shortly after the recovery of motor function was complete and constant. The tendency to variation is also observed in the sensory field, so that two successive examiners may record apparently contradictory findings. In one case as yet unproved, but in which the clinical findings were classical of a venous disturbance, the sensory examination was particularly difficult, no two examiners obtaining the same finding.

The disturbances of sensation in arterial disease are mainly those of pin prick appreciation while so-called cortical sensibilities may be preserved. There is no fluctuation; the pattern remains unchanged until recovery takes place.

#### PROGNOSIS

As observed in the cases studied, the general tendency is toward a complete recovery. In two cases previously reported and in the three cases in this paper, there was virtually no damage to the brain tissue itself during the operative procedure. As noted, there was no damage to an important arterial twig. All technical surgical steps took place high on the cerebral cortex immediately adjacent to the sagittal sinus. In but one case was there direct interference with this sinus, and this occurred in Case III, in which an extensive segment was removed. The immediate postoperative

TABLE III\*

Arterial (Internal Capsule)	Venous (Superior Cortical Surface)
1. Soon established and complete.	May be transient, repeated attacks of weakness before paralysis is established.
2. The onset is usually precipitate.	Progressive onset.
3. Clinical picture of shock—pallor, cold, clammy skin.	Color good.
4. History obtained from others.	Able to give own story.
5. Often unconscious; cloudy sensorium.	Mentally alert.
6. Aphasic or dysarthric speech.	No disturbance of speech.
7. Marked supranuclear facial paralysis—protracted.	Transient or absent facial weakness.
8. Face, arm, particularly the hand, most paralyzed.	Lower limb involved most severely.
9. Flaccidity of paralyzed side ten to twelve days.	Immediate or early rigidity (plastic type).
10. Increase of tone during recovery (spastic) with return of function.	Fluctuation in tonal state; decrease in tone during recovery.
11. Early absence of deep reflexes; no early change.	Marked variation in the reflex state; early hyperactivity or absent reflexes.
12. Pain is modality of sensation most disturbed; all modalities may be lost; little variation.	Gnostic or cortical loss two-point muscle joint and tendon sense; pain may be undisturbed; variations day to day.
13. Recovery of muscle power usually occurs first in the lower limb, finger movements late or not at all.	Lower limb last to recover; finger movements recover first, then elbow and shoulder.
14. A steady progressive recovery.	Marked fluctuation in the motor power during recovery, shifting from complete paralysis to good function and back to paralysis in an hour's time.

\* Represents the contrast in findings in a hemiplegia caused by arterial occlusion (capsular) and one induced by obstruction to the drainage of the rolandic veins.

findings were caused by temporary interference with the drainage of the important rolandic vein. It is debatable whether an actual thrombosis necessarily occurs, stasis itself being sufficient to provoke the picture. Recovery is dependent upon circulatory adjustment, possibly in the rolandic

vein or through other venous anastomotic channels. According to Holmes and Sargent, if "the brain itself has not been at the same time damaged by the missile the symptoms due to obstruction of the venous circulation diminish gradually, and will eventually disappear, almost or entirely;—the degree and rate of improvement may depend as much on the inconstant anatomical arrangement of the veins and the amount of anastomosis between the two lateral venous systems as on the severity of the lesion."

### CONCLUSIONS

A further elaboration of the syndrome of the rolandic vein is presented. Three additional cases are given in which the clinical manifestations follow the pattern previously observed in interference with the drainage of the rolandic vein.

These characteristics in the main are early rigidity, gnostic type of sensory disturbances, and a motor paralysis frequently sparing the face, with a fashion of recovery beginning first in the hand, the foot being the last to regain motor power.

Also the literature of deliberate surgical resection of the sagittal sinus has been surveyed. A tabular listing of the reported cases together with other personally communicated cases is added.

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# THE MANAGEMENT OF MALIGNANT TUMORS IN THE GROIN\*

## A REPORT OF 122 GROIN DISSECTIONS

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### INTRODUCTION

IN the course of study of a series of 400 malignant melanomas treated at the Memorial Hospital more than three years ago, the most interesting and rueful conclusions concerning treatment had to do with the previous management or mismanagement of melanoma metastatic to lymph-nodes in the groin. The extremely bad results were so shocking as to stimulate a more rational and radical plan of treatment which has been pursued now for more than three years. The purpose, therefore, of this article is to present the details of procedure as now employed and the end results, lamentably poor as they are, of 122 groin dissections performed during the past twelve years. Of these 122 groin dissections, forty-one were bilateral, sixty were for metastatic melanoma, fifty-five were for metastatic epidermoid carcinoma and seven were for primary sarcomas of the soft somatic tissues occurring in the groin.

As the radical procedure is of more recent adoption, the greater number of these dissections herein reported were of the superficial character and perhaps should be analyzed separately. The so-called radical dissection, which will be described in detail, has been done for current cases during the past three or four years so that long term comparative follow-up studies are not possible.

In addition to metastatic melanoma involving the groin it was decided to study the comparative behavior of epidermoid

carcinomas, capable of metastasizing to the inguinal, femoral and iliac lymph-nodes. The sequence of events for malignant melanomas and epidermoid carcinomas of the lower extremity, for example, parallel each other in some respects but the time relationships and end results are divergent. The melanomas constitute the more interesting study because of the high incidence of nodal involvement and the necessity for radical surgical intervention. Of the 122 patients who had groin dissections and are the basis of this report, forty-four of sixty who had malignant melanomas and thirty-five of fifty-five who had epidermoid carcinomas, presented definite evidence of metastasis in groin nodes on admission. Under the indications for groin dissection subsequently listed, will be noted the advantages of elective dissection in the case of melanoma, even though no clinical evidence of metastasis to groin nodes are evident. The more conservative policy of waiting for proof of metastatic involvement of lymph-nodes in the groin by epidermoid carcinomas is generally followed. In our experience, for example, 24 per cent of patients with epidermoid carcinomas of the hands and feet and without palpable regional lymph-nodes, subsequently developed nodal metastases while under observation. If dissection of these regional lymph-nodes had been routinely done on admission, 75 per cent of them would have been unnecessary.

The value of groin dissection for metastatic cancer is generally admitted. No

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substitute such as radiation therapy has proved to be satisfactory. An operative mortality of less than 2 per cent is a small risk for the treatment of an otherwise lethal disease. The end results obtained fully justify the hazards of the operation. The frequency of local recurrence in the groin following the usual superficial dissection offers a strong argument for the more frequent employment of the radical operation, in which the dissection is carried above the inguinal ligament. Basset popularized the radical groin dissection, which has consequently been given the eponym of Basset's operation. Taussig improved this procedure by laying open the inguinal canal, ligating the deep epigastric vessels, removing the iliac lymph-nodes and occasionally severing the inguinal ligament. Staeckel combined an abdominal and inguinal approach to the dissection of these lymph-nodes with an operative mortality of 11 to 15 per cent. The scope and details of the radical groin dissection as we conceive and practice it, will be shown in the following text and illustrations:

#### INDICATIONS FOR GROIN DISSECTION

Exclusive of certain primary liposarcomas, rhabdomyosarcomas and neurosarcomas which occur by chance in the groin and have no predilection for this location, a greater number of groin dissections are performed for metastatic cancers, either malignant melanoma or epidermoid carcinoma, occurring in the skin of the inferior extremity, male and female genitals, the perineum, peri-anal zone, gluteal region and the infra-umbilical segment of the abdominal wall. The wisdom of performing a groin dissection for clinically recognizable metastatic cancer in the groin is generally accepted. The value of performing bilateral groin dissections for metastatic cancer known to be present in the right and left inguinal groups remains debatable in some schools, but there is sufficient evidence to justify the conclusion that cure is still possible even in these circumstances. The umbilicus, the

infra-umbilical or midabdominal skin, the skin of the anus and scrotum, the peri-anal zone and the female genitals all may be involved by cancers which are capable of metastasizing either to the right or the left group of groin nodes or to both groups. The bilaterality of this extension indicates the necessity for bilateral groin dissections, either in one or two stages. Furthermore, the entire procedure of excision of the primary and metastatic cancers in both groins may be performed in one, two or three stages but the preferable procedure, of course, is to excise the primary cancer and the lymph-nodes in both groins *en bloc*, without interrupting the lymphatic connecting pathways, if this is at all possible technically and if the patient is in condition to tolerate such a major ordeal.

Among the postulates for successful groin dissection are the following: (1) The primary cancer, wherever located, should be controlled or controllable and should be treated first. (2) There should be no clinical evidences of blood stream metastases. (3) The lymph stream must be centralward without evidence of blockage and retrograde extension. (4) It should be technically possible to excise all of the lymph-nodes involved or suspected of becoming involved in the immediate neighborhood. (5) There must be some possibility of interruption of the lymphatic spread of the cancer by an excision of these nodes. As an example of this contraindication, one could cite the extension of a carcinoma of the vaginal introitus inward to involve the vaginal mucosa. (6) There should be evidence that the cancer has drained only to the regional groups of nodes to be attacked in the groin dissection.

In aged patients or those in extreme debility, a radical groin dissection as described in this article may necessarily be modified or may have to be abandoned as unfeasible; but barring no such contraindications, it finds suitable application as described in the adjoining context. If the metastatic cancer in the inguinal nodes is too intimately adherent to the femoral or

external iliac vessels as to permit complete local excision, all thought of the operation should be abandoned.

Groin dissection is usually hopeless in the event of numerous secondary nodules in the skin of the lower extremity, intervening between the site of primary tumor and the groin. Even such a radical procedure as groin dissection associated with hip joint disarticulation will not afford an opportunity for cure. This is particularly true in the case of malignant melanoma because this tumor at the time of such widespread local extension has usually invaded some blood vessel with resultant distant metastases.

Of the patients who at some time in the management of their disease, underwent the experience of groin dissection, forty-four of the sixty individuals who had malignant melanoma and thirty-five of the fifty-five who had epidermoid carcinoma, had definite evidence of metastatic involvement of groin nodes on admission.

#### ELECTIVE GROIN DISSECTION

The caption, "elective," is a misnomer that is used here for the want of a better term. The operation called by this name refers to the elective removal of lymph-nodes in the groin even though they are not palpable and there is no clinical evidence of metastases being present. It is the authors' opinion that this dissection should be done routinely for all melanomas of the extremity and genitals. In a group of seven dissections of this type for melanomas of the lower extremity, two of the patients were found to have microscopically identifiable melanoma in the inguinal lymph-nodes even though the surgeon at the time of operation found no gross evidence of involvement. In another group of ten similar axillary dissections for melanoma of the upper extremities, five or 50 per cent of the series showed microscopic evidence of metastases to the lymph-nodes even though there was no gross evidence determinable preoperatively or during the course of the operation. It is our contention that this

early operation, although needlessly done in some instances, affords the patient with metastatic melanoma in the groin a better and earlier opportunity of cure. It seems reasonable that the fewer lymph-nodes involved and the earlier the involvement, the better will the prognosis be. In the case of epidermoid carcinoma, occurring in the lower extremities, this routine dissection is never performed, as one waits until there is evidence of involvement. The reason for this is that this type of cancer does not so frequently metastasize to inguinal nodes and there is a natural wish to avoid unnecessary operations of this major character. For epitheliomas of the scrotum and vulva, however, it is our belief that the bilateral inguinal dissection is constantly indicated even in the absence of palpably enlarged lymph-nodes.

There is no urgency in doing this groin dissection as an elective procedure, as we have shown that an average time of fifteen months elapses from the time the primary melanoma is recognized before the metastases in inguinal nodes are apparent. As a rule, six weeks are permitted to elapse after the primary melanoma has been surgically excised before the second stage or elective groin dissection is done. Patients who refuse this procedure are kept under close and frequent observation. This principle of elective groin dissection is based on a study made several years ago of all malignant tumors of the extremities, which revealed the distressing information that radical dissection of the primary melanoma often was not curative in itself, even in patients in whom no regional lymph-nodes were palpable, because a considerable number of these patients would return during the observational period with large confluent nodes containing metastatic melanoma which was not observed at the previous visit.

#### SEQUENCE OF TREATMENT OF PRIMARY CANCERS AND METASTASES IN THE GROIN

It is not an indifferent matter to decide whether to remove the primary cancer or

to perform a block dissection of the regional lymph-nodes as the first step in a two-stage procedure. It is a source of great wonderment to read how frequently surgeons advise the dissection of regional lymph-nodes as the initial step of treatment, leaving the management of the original cancer to a later date. Such a plan completely ignores the natural evolution of any cancer. The first tenet necessary for a successful groin dissection is that the primary cancer is cured, controlled or controllable. The plan of treatment wherein groin dissection is first performed, delaying the excision of the original cancer to a later date, is fraught with great dangers. The original cancer does not remain quiescent in its growth during the interval elapsing before treatment is applied directly to it. Metastases continue to occur either intermittently or progressively and these cancer cells, therefore, behave in one of two fashions: either they are poured out directly into the fresh wound of the groin where there is always abundant exudation of lymph and in so doing may produce a widespread locally infiltrating incurable recurrence; or, if the wound is healed to the point where the severed lymphatics are obstructed by the developing scar, the lymph stasis affords the proper setting for lodgment of emboli and retrograde lymphatic permeation, so that by the time the primary cancer is attacked the disease will already have extended superiorly beyond the scope of excisional surgery. The ideal procedure of course is to be able to remove primary cancer and a metastatic cancer *en bloc* which can be achieved in some instances, in malignant tumors of the genitals, for example. But in the case of melanomas of the inferior extremity, a multiple-stage procedure must be usually worked out. We have found from experience that it is unwise to remove a melanoma or epithelioma of the foot and at the same time dissect the groin even though metastases are evidently present, because even here there may be metastases en route.

It requires a nicety of judgment to decide on the interval of inaction when metastases are known to be present and even then the wrong decision may be made. Ten to fourteen days at the most are permitted to elapse before the second stage or groin dissection is accomplished. In the past, the primary cancer, e.g., a melanoma on the foot, and the lymph-nodes in the groin have been removed at a single operative seance only to be followed in too many instances by the appearance of innumerable subcutaneous and intracutaneous nodules along the lymph pathways in the leg and thigh. It is our theoretical belief, substantiated only by personal experience, that the lymph-nodes in the groin should remain to exercise their function as catchment basins or filters for cancer cells which may be metastasizing at the time the primary cancer is removed. The groin dissection should not be postponed too long, if metastases are clinically evident, otherwise the hazard exists of secondary metastasis to the next higher relay or chain of nodes, too far removed superiorly to be surgically excised.

The interval between the first appearance of the primary lesion and the known recognition of metastasis in lymph-nodes of the groin is not the same for all malignant tumors. In the Memorial Hospital series, the interval for epidermoid carcinoma is thirty months and for malignant melanoma only fifteen months, which is in agreement with the usual greater degree of malignancy and the more rapid growth of melanoma. At the two extremes, there is one case report of an instance in which metastasis in the inguinal nodes appeared twelve years after an epithelioma of the foot had been treated and other examples of the simultaneous discovery by the patient of a primary melanoma of the clitoris or vulva and enlarged inguinal nodes, obviously the site of metastatic deposit. The delayed enlargement of these nodes after a lapse of several years indicates that metastases had been present all the

time but remained dormant or latent for some unexplainable reason.

#### TECHNIC OF RADICAL GROIN DISSECTION

The patient is placed on the table with the corresponding thigh slightly abducted

The skin incision differs from those previously described by Basset and Tausig inasmuch as it entails the removal of a wide ellipse. (Fig. 1.) The motives for removal of the skin are several: it lessens the possibilities of local skin recurrence; it

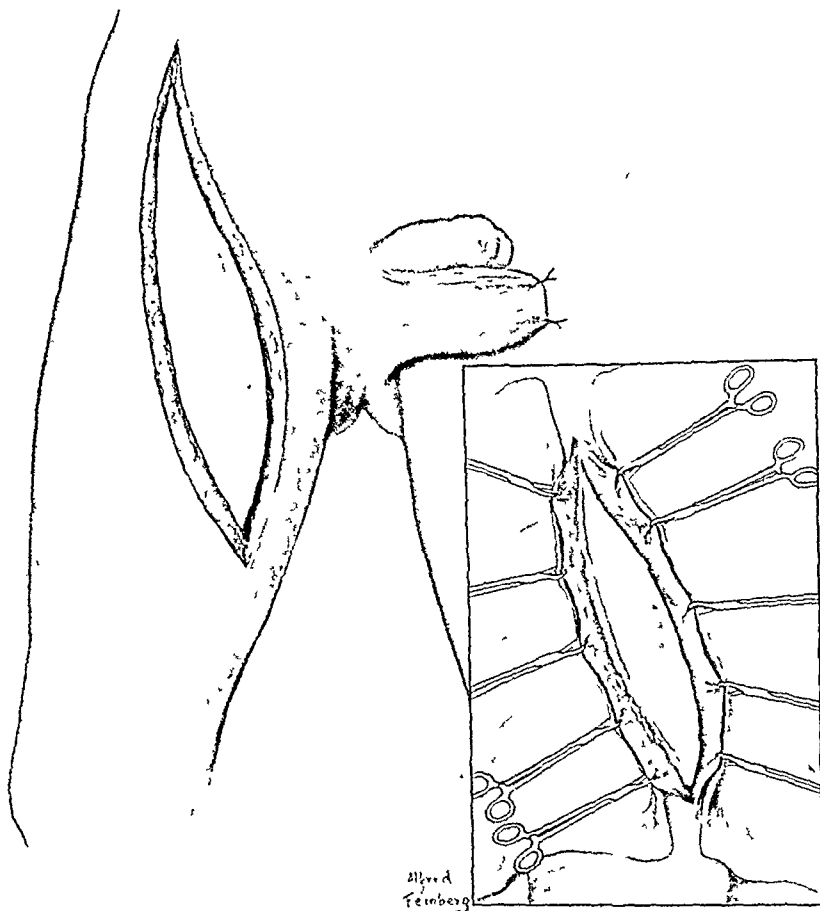


FIG. 1. Scope of incision for groin dissection. The ellipse permits necessary sacrifice of condemned skin. Note direction of incision and upper and lower limits. Scrotal skin is sutured temporarily to opposite thigh. Insert shows use of tenacula to facilitate subcutaneous and fascial dissection.

and externally rotated, with the knee slightly flexed over a small sandbag. In the male, the scrotal skin is superficially sutured to the opposite groin, which adequately withdraws the genitals from the operative field. There are no indications for the specific use of various anesthetics. The majority of the operations are performed under spinal anesthesia, which affords good muscular relaxation during the ninety minutes required for the operation.

avoids the almost inevitable death and sloughing of the skin which follows the wide fascial dissection which is to be described and it hastens wound healing. The upper extremity of the incision is situated two inches above and one inch medial to the anterior superior iliac spine. From there it sweeps downward in a wide ellipse and then in a medial direction over the inguinal region, then the femoral trigone, to terminate at its lower extremity in the midthigh overlying Hunter's canal. After the skin

edges are defined by the scalpel, sterile towels are applied to the lateral wound edges by means of numerous tenacula

ligated near its junction with the femoral vein. The dissection proceeds from above downward, removing all the fascia from the



FIG. 2. Superficial stage of groin dissection partly completed. Skin flaps dissected widely back. Lower abdominal, inguinal and femoral regions freed of fat, fascia, lymphoid and areolar tissues from above downward. Observe medial and lateral extent of fascial dissection.

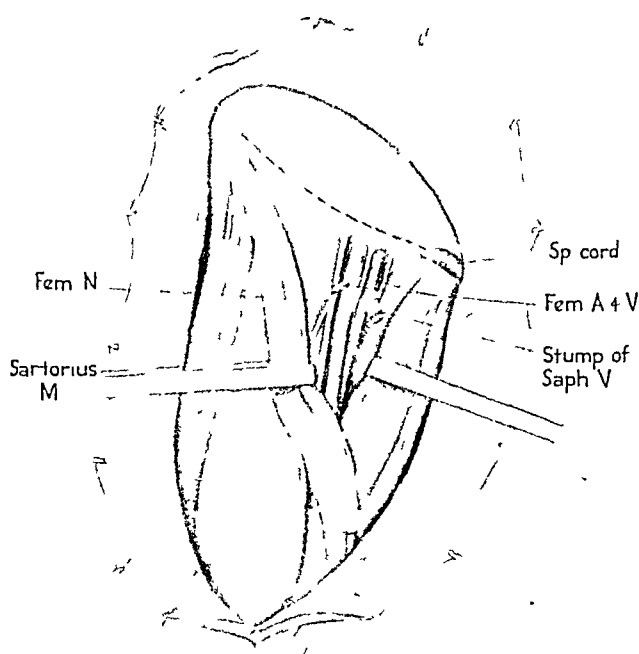


FIG. 3. Completion of superficial stage of groin dissection. The neurovascular femoral bundle has been cleanly dissected down through Hunter's canal. The fascia overlying the pectineus, iliacus, sartorius, adductor brevis and rectus femoris muscles has been removed. Proposed incision to expose the inguinal canal is indicated by the dotted line.

which are very helpful in facilitating subsequent dissection of fat and fascia from the skin. With the tenacula elevated, the subcutaneous fat is now dissected widely in all directions until the entire upper third or two-fifths of the anterior thigh, the inguinal region and lower abdominal wall over the iliac quadrant has been denuded of skin. The dissection now persists deeply to the underlying muscles, through the fascia, which is dissected with the fat and the lymphoid tissues *en bloc* in a medial direction. This dissection is started from above downward, exposing the inguinal canal and finally the femoral vessels. (Fig. 2.) The adventitial layer of the artery and vein is stripped together with the fat and fascia intervening between these vessels. The external saphenous vein is severed and

muscles of the anterior thigh (sartorius, iliacus, pectineus, adductor brevis, rectus femoris). The sartorius muscle is retracted as the dissection proceeds down through Hunter's canal. The external saphenous vein is again severed and ligated where it enters the operative field overlying the middle segment of the sartorius muscle. This bulk of tissue is then removed and the first stage of the groin dissection is considered complete. (Fig. 3.)

At this point the second step is carried out, giving exposure of the inguinal canal which is incised from the external ring to the point where the round ligament or spermatic cord dips downward into the pelvic cavity. The canal is further exposed laterally by incising the external oblique fascia and the transversalis muscles down

to the properitoneal fat. The occasional lymph-node in the inguinal canal is sought for and removed if possible. The external

operative field except the normal structures necessary to reconstruct the inguinal ligament and canal.

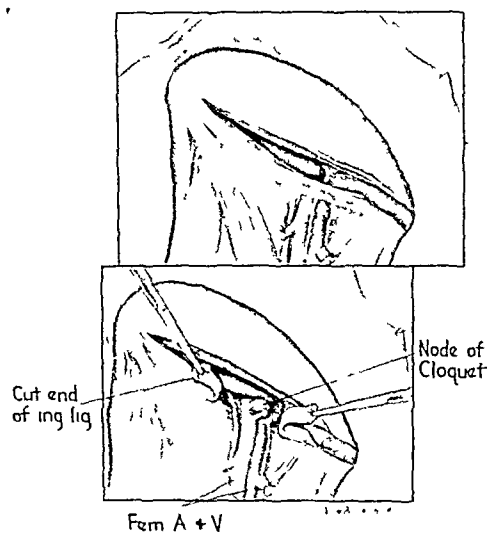


FIG. 4. Exposure of inguinal canal, severance of inguinal ligament and surgical entry into the right retroperitoneal iliac region.

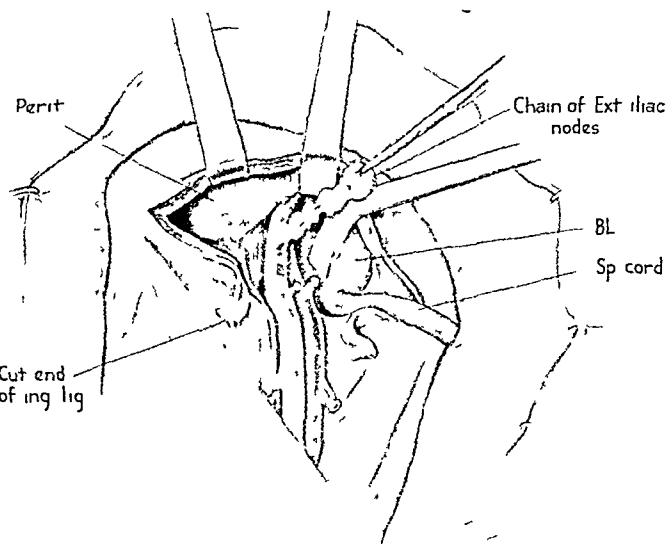


FIG. 5. Dissection of deep iliac lymph-nodes. Displacement of peritoneum medially to afford adequate exposure.

oblique fascia and the inguinal ligament are then severed about two inches from the attachment to the pubic spine. This maneuver opens the femoral ring and improves the exposure of the vessels and lymphoid tissues situated retroperitoneally along the iliac vessels. (Fig. 4.) The lymph-node of Cloquet is usually found resting anteriorly on the femoral vessels just within this ring. In order to secure even greater exposure, deep retractors are inserted to withdraw the peritoneum and abdominal viscera upward and medially out of the operative field. The peritoneal cavity is not entered during the dissection which is carried out entirely retroperitoneally. The chain of lymph-nodes, fat and areolar tissue found along the external iliac vessels are dissected from above downward, including those overlying the obturator foramen. (Fig. 5.) This exposure may be materially aided by preliminary ligation of the deep epigastric vessels where they come off at right angles from the external iliac artery and vein. The entire groin dissection is performed with the scalpel and at the completion of the operation practically no fat nor fascia should be left in the

Some surgeons have stressed a preference for performing the external iliac dissection first, continuing with the inguinal femoral dissections later. The advantages of this sequence are more theoretical than practical. The completion of the preliminary superficial dissection affords a more adequate exposure so that the subsequent or continued deep iliac dissection may be radically performed. The inguinal canal is then closed in the manner customary for herniorrhaphy. The inguinal ligament is reconstructed and sutured around the femoral vessels without occluding them. The sartorius muscle is sometimes lightly sutured medially in an attempt to obliterate the so-called "dead space" of Scarpa's triangle and to protect the femoral vessels more adequately. All bleeding vessels are tied with silk ligatures which in our experience has greatly lessened the quantity of serous discharge. The serum which accumulates may be removed by aspiration. If the tumor is fungating through the skin or an irradiation ulcer is present, catgut ligatures are employed and drainage is established through a standard incision placed in the most dependent portion of the



wound on its medial aspect. The skin is usually closed by interrupted silk sutures.

#### POSTOPERATIVE CARE

The thigh is maintained in slight flexion in order to lessen the tension on the wound edges and to permit the natural fold of the groin to form. It is essential to bring the skin against the underlying muscles otherwise an accumulation of serum soon occurs. A large sterile sea sponge wrapped in gauze is applied over the wound and held in place by a spica bandage. The pressure thereby exerted must be uniform and of the right degree in order to obliterate the dead space and yet it must not be too great for fear of wound necrosis.

#### COMPLICATIONS

1. *Operative Mortality.* The lethal dangers are immediate or delayed hemorrhage, pneumonia, embolism, septicemia and shock. The hazard of the radical operation is undeniably greater than the superficial groin dissection. The mortality rate is increased when bilateral dissections are done and when groin dissection is done at the same time as vulvectomy, or amputation of the penis or lower extremity. There were two operative deaths in our series of 122 groin dissections of which forty-one were bilateral; the mortality rate therefore was 1.6 per cent. The operative mortality reported by Staeckel was 15.2 per cent for the radical operation and 4 per cent for the more superficial groin dissection. Taussig's operative mortality for groin dissection associated with vulvectomy for cancer was 5.2 per cent.

2. *The complications of pneumonia, atelectasis, heart failure and embolism* occur with the usual frequency in patients who have lower abdominal operations.

3. *Hemorrhage.* Hemorrhage during the operation has never occurred in our personal experience, but it was a complication in one of the groin dissections performed on the mixed tumor service and is reported herein. The common cause of hemorrhage has been late wound necrosis with slough-

ing and secondary hemorrhage from the femoral vessels due to ill advised preliminary radiation therapy. In one instance, the hemorrhage could be attributed to invasion of the blood vessels by the tumor. There were five postoperative hemorrhages, one of which was fatal (4 per cent).

4. *Wound Infection.* Thirty-two of the 122 groin wounds were badly infected, an incidence of 26 per cent. The wound is almost invariably infected to a certain degree due to the frequency of necrosis of the wound margins. One recent severe infection due to hemolytic streptococci occurred and responded well to chemotherapy. The usual methods of treating wound infections are in order, the most important of which is the establishment of adequate drainage. Gauze impregnated with zinc peroxide and hydrogen peroxide is packed in the wound and hastens sequestration of the slough.

5. *Delayed Wound Healing.* This complication occurred in forty-nine patients or 40 per cent of the groin dissections. The very nature of the operation interferes with the blood supply to the skin flaps. The skin margins of the wound usually survive from four to eight days before the necrosis becomes manifest and demarcation of the dead skin is established. It is well to wait until the necrosis is fairly complete before proceeding with débridement. Delayed wound healing is of some concern to the patient, but really offers no great handicap. This complication has occurred more frequently than necessary in our reported cases because of previous radiation therapy.

6. *Necessity for Skin Grafting.* Twenty-four of the 122 patients required skin grafting, an incidence of 20 per cent. Secondary or delayed skin grafting is always done if the resultant defect is large. It hastens the convalescence of the patient, insures a scar of greater integrity and lessens the degree of lymphedema.

7. *Lymphedema of Lower Extremity.* Lymphedema of the entire lower extremity inevitably follows the radical operation of dissecting the external iliac lymph-nodes.

This lymphedema is apparently increased by the degree of infection and the consequent tightness of the scar. The primary concern is not for the cosmetic disfigurement, the added weight or the discomfort caused by such a leg, but rather for the predisposition to severe recurrent infection with high fever and prostration which sometimes occur. This disturbance between the arterial and lymphaticovenous balance may not be permanent as pointed out by Reichert. The stasis of the lymphaticovenous system provides a stimulus for the regeneration of the lymphatics during the immediate postoperative state. Subsequent attempts at correction may be made either by use of a Kondoleon operation performed in multiple stages or by a Handley lymphangioplasty.

#### RADIATION THERAPY OF METASTATIC CANCER IN THE GROIN

Radiation therapy of metastatic cancer in the groin is not a curative procedure. At the Memorial Hospital, radium and x-rays have been used for twenty years in the vain effort to control this disease. Both external and interstitial irradiation in all the various plans of distribution, from massive single doses to fractionated treatments, have been used without a single instance of five-year cure. Some patients have lived for five to ten years following such treatments, but no microscopical proof of the presence of metastatic cancer is available in these instances. In all analyzed case reports in which biopsies of groin nodes have unequivocally proved the presence of cancer, the patient has died of the disease or of the complications attendant on irradiation. These findings apply both to melanoma and epidermoid carcinoma metastatic to the groin, from such primary sources as skin of the lower extremities, buttocks, lower abdominal wall, vulva, anus and scrotum.

There are numerous factors to account for these failures. Malignant melanoma and the types of epidermoid carcinoma which metastasize to these nodes are

notoriously radioresistant. This radioresistance is of such a degree that even the primary cancer is seldom treated solely by irradiation. The skin of the groin is extremely delicate and has an unusually poor blood supply so that it will not tolerate doses of radium and x-rays such as are commonly administered through the integument elsewhere as in the neck. The constant moisture aggravates the radiation reaction and impedes the healing process. The lymph-nodes of this location have delicate capsules which are early perforated by the metastatic cancer, which invades the surrounding fat so that growth restraint through swelling of the nodes, ischemia and necrosis, such as occurs in cervical nodes following irradiation, does not occur in the groin. The portal of the area to be irradiated would necessarily have to be very large and this would limit the dose of external irradiation which could safely be given. In contradistinction to the cervical nodes, it is often difficult if not impossible to determine by palpation the involvement of the inguinal nodes by metastases. The late effects of radiation treatment are often disastrous. The skin becomes fibrosed, telangiectatic, hyperkeratotic and dry due to atrophy of the sweat and oil glands. Late ulceration or radionecrosis tardive frequently ensues within six to twenty-four months or later. Such complications often terminate in fatal hemorrhage from the femoral vessels. Interstitial irradiation of inguinal and femoral lymph-nodes is only too often followed by tissue breakdown and a resultant necrotic, infected, painful ulcer which resists all efforts to facilitate healing other than radical surgical excision.

Furthermore, delayed groin dissections in the presence of late radiation changes in the tissues, often associated with ulceration and infection, are hazardous because of the dangers of immediate or late hemorrhage in addition to possible continued extension of the tumor. The operation is technically difficult for several reasons, namely, the degree of fibrosis which handicaps clean

surgical dissection, adhesions to the femoral vessels, and the necessity of sacrificing all of the irradiated skin. The defect in the

lymphatic vessels. As in other parts of the body, almost all of the nodes of the extremity are grouped in the flexor regions

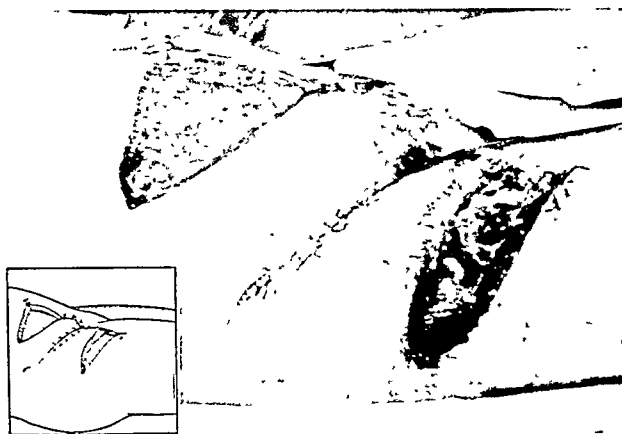


FIG. 6. Groin dissection with excision of fibrotic, telangiectatic, radionecrotic, ulcerated skin and closure of defect over exposed femoral vessels by transposed sliding skin flaps. The triangular defects were then closed by Thiersch grafts. The heavily irradiated, damaged skin in the groin proper was removed as it never would have healed.

groin following this procedure cannot be covered well by immediate or secondary skin grafts of the Thiersch or Reverdin types. In lieu of this, transposed skin flaps from the thigh and lower abdomen are necessary to effect a closure of the wound over the exposed blood vessels. (Fig. 6.)

The lymphedema of the leg following such irradiation is fully as great as that which occurs after a radical surgical excision and, in addition, the groin is often painful on motion. In conclusion, therefore, one may definitely state that radium and x-ray therapy are contraindicated for the treatment of metastatic cancer in the groin. Such tumors as primary or generalized lymphosarcoma involving the groin are best treated by x-rays or external radium applications. This is the sole tumor deserving the employment of these agents.

#### SURGICAL ANATOMY OF LYMPH-NODES IN THE GROIN

There is a certain regional uniformity in the distribution of lymph-nodes in the popliteal, femoral, inguinal and iliac groups. These lymph-nodes are placed with anatomical precision along the course of the

of the joints, e.g., popliteal space and the groin.

The inguinal nodes, as we employ the term, refers to all lymph-nodes in the inguinofemoral region. The superficial inguinal lymph-nodes, which average eight to twelve in number, are arranged in four main groups, namely, the superolateral, superomedial, infralateral and inframedial series (Rouvière-Tobias). These superficial inguinal lymph-nodes drain the major number of superficial lymph vessels from the skin of the lower extremity, the labia majora and minora, the praeputium clitoridis, the scrotum, the penis, the buttocks, the perineum, the lumbar, umbilical and infra-umbilical regions and the cutaneous zone of the anus. Some of these lymph-nodes intercommunicate with each other by means of short lymph pathways, but not all intercommunicate.

The chief efferent lymph vessels from the superficial nodes extend either directly into the external iliac lymph-nodes above the inguinal ligament or to the deeper inguinal nodes beneath the fascia. These deep lymph-nodes and those of the retrofemoral group are usually of small size and

few in number, scarcely more than three or four. They are situated laterally and medially to the femoral vein and the uppermost one of this chain is the so-called lymph-node of Cloquet or Rosenmüller which is between the femoral vein and the lacunar ligament. The deep inguinal and retrofemoral lymph-nodes receive the majority of lymphatics accompanying the femoral blood vessels and in addition efferent lymphatics from the superficial inguinal nodes, as previously related, and from the glans penis and glans clitoridis. The efferent trunks from the deep inguinal nodes extend directly into the external iliac lymph-nodes. (Fig. 7.)

These anatomical facts concerning the locations and intercommunications of the nodes in the inguinofemoral and external iliac groups are helpful in enabling the surgeon to anticipate the extension of melanomas and epitheliomas into the groin. The study of these pathways once again confirms the necessity for a radical groin dissection to include the deep inguinal, retrofemoral and external iliac nodes as well. Otherwise, a certain number of patients may not be cured by the more superficial dissection even though the superficial lymph-nodes reveal no microscopic evidence of metastatic cancer.

The apparent number and size of the nodes seem to be influenced by the age of the individual. For example, patients with malignant melanoma are usually of a younger age group and the lymph-nodes appear to the surgeon and pathologist as being more frequent in number, whereas the epidermoid carcinoma of the extremities and genitals occurs in elderly subjects in whom the lymph-nodes seem to have regressed or atrophied with age. An explanation is in order here. Although the lymph-nodes in older people appear to have vanished, they really undergo involution and diminish in size; they do not actually disappear. The presence of infection or even of metastatic cancer in the groin may cause these lymph-nodes to enlarge and become detectable even though

not involved by metastases. It often proves confusing to the surgeon as it is not always possible on inspection to determine whether

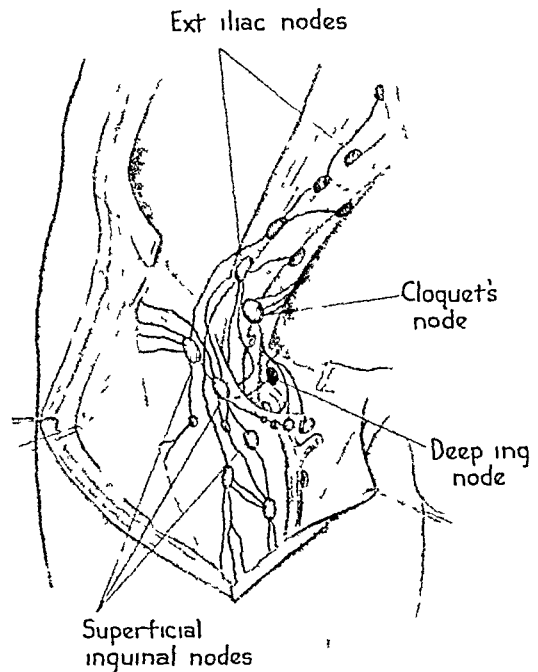


FIG. 7. Distribution of lymph-nodes in the groin (after Rouviere). The superficial inguinal lymph-nodes drain the major number of superficial lymphatics from the lower extremity. The deep inguinal and retrofemoral nodes receive the lymphatics accompanying the femoral vessels. Both groups communicate and may empty into the higher chain of deep iliac lymph-nodes.

or not metastatic cancer is present. The lymph-nodes may involute or regress to a size comparable to the head of a pin, but they do not entirely disappear. On this account, a dissection of the groin and particularly the tissues along the femoral and external iliac vessels must be meticulous in order to remove each and every one of these small intercalated nodes. If a groin dissection has been performed for metastatic cancer and a local recurrence develops which proves on study to be metastasis in a lymph-node, it may be assumed that the dissection was not complete. Lymphatic vessels after severance may re-establish connection across the wound, but lymph-nodes *per se* never regenerate.

PATHOLOGICAL PHYSIOLOGY OF LYMPHATICS  
DRAINING INTO OR RELATED  
TO THE GROIN

The dissemination of melanomas and epidermoid carcinomas of the lower extremity, male and female external genitals, skin of the lower abdomen and buttocks may be by direct extension through the planes of tissue cleavage, by blood vessel invasion and vascular metastasis, and by lymphatic embolism or permeation. Direct extension of these tumors occurs through homogeneous tissues along the clefts and tissue cleavage planes which generally offer the lines of least resistance. This extension, therefore, is dependent on physical or mechanical factors governed by such barriers as fascia, capsular sheaths and periosteum. This method of extension is best exemplified in our experience with the liposarcomas, neurosarcomas and rhabdomyosarcomas of the upper thigh and groin and the bulky confluent metastatic melanomas and epidermoid carcinomas of the groin which have perforated the capsules of the lymph-nodes.

Invasion of blood vessels occurs with some frequency by melanomas, seldom by epidermoid carcinomas, except in the rare spindle cell type which develops on the basis of radiation dermatitis and acrodermatitis chronica atrophicans. This route of spread is the result of an infiltrating tumor, which invades the walls of a vein and penetrates into the lumen where it proliferates. Tumor cells then break off and metastasize by embolism widely to the viscera. Arterial wall invasion in the femoral artery with terminal metastases in the toes and foot has been reported, but it is of rare occurrence. The surgeon is occasionally surprised to find that a mass in the groin surgically excised and presumed to be metastatic cancer in femoral lymph-nodes may prove to be a tumor thrombus in the vein, usually one of the tributaries of the saphenous. The prognosis under such circumstances is usually bad because of the likelihood of distant metastases.

In many ways the lymphatic routes are more important. They form an abundant lymphatic network beneath the skin and drain into primary and secondary lymph-nodes arranged in series and ultimately feed into blood vessels. The lymphatic vessels are especially abundant and of greater intricacy in the locations where skin and mucous membranes meet, i.e., mucocutaneous junctions, such as in the vulva, anus and prepuce. Cancer cells may spread through the lymphatic vessels either by lymphatic permeation or by embolism. Lymphatic permeation or lymph-vessel carcinosis or melanomatosis refers to the direct extension of proliferating cancer through a system of preformed crevices or channels, namely, the lymphatics. The occurrence of this phenomenon, especially in the case of melanomas of the extremity and genitals, has been proved by microscopic studies which show in serial sections the presence of a cord of tumor tissue in the lymphatics, whether they be interstitial, perineural or perivascular. The usual direction of extension corresponds with the flow of lymph. In the case of melanomas of the extremity, the affected lymphatic vessels may occasionally appear as black or bluish cords, extending between the primary melanoma and the regional lymph-nodes. Sampson Handley has laid considerable emphasis on this theory as the key to carcinomatous dissemination particularly in the breast, but Willis asserts that it constitutes only one method of dissemination and that a great majority of malignant tumors do not follow this path. In our experience with tumors metastasizing into the groin, lymphatic permeation occurs more frequently by melanomas and only occasionally by epidermoid carcinomas in which the inflammatory element is prominent and in which there is co-existent lymphedema. The process of lymphatic permeation may be simulated by a blockage along the lymphatic pathway so that subsequent backing-up occurs with successive showers of emboli.

The embolic theory of dissemination is more generally accepted and undoubtedly explains a greater number of metastases to groin nodes. Many pathologists have repeatedly examined tissues intervening between the primary carcinoma or melanoma and the lymph-nodes draining these neoplasms and have been unable to detect tumor cells in the intervening or connecting lymphatics, although this may occur in lymphatic permeation which seems to be the exception rather than the rule. The embolic method of spread in the lymphatics of the genitals and lower extremity is proved by certain well known facts. In the fatal cases of melanoma and epidermoid carcinoma there is a high incidence, approaching 100 per cent, of lymph-node involvement. The patient and the physician may observe a large palpable lymph-node in the groin containing metastatic cancer as the first sign of the disease, before the primary tumor, particularly melanoma, becomes apparent. Furthermore, there is a large number of reported cures secured by adequate treatment of primary melanoma or epithelioma of the foot or genitals and proper surgical excision of the femoral and inguinal lymph-nodes only, without any treatment whatsoever to the intervening normal tissues.

Once the cancer is in the lymph-node, it may spread by secondary embolism or even by permeation to another node or chain of nodes. Wherever the involved lymph-nodes are in close anatomical relationship to the femoral or external iliac veins, they may give rise to blood stream invasion and subsequent dissemination. Not all blood-borne metastases can be explained by this phenomenon, however, as some occur due to direct invasion of small veins by the primary tumor and in other instances the small veins of the lymph-node itself may be invaded.

#### RETROGRADE LYMPHATIC SPREAD

The direction of the lymph stream is normally determined by the lessened resistance of the expanding vessels, by the

direction of the valves in the lymph vessels, and by the character of muscle pressure exerted. Lymph flow is usually sluggish and



FIG. 8. To illustrate the possibilities of retrograde lymphatic permeation. This woman had a carcinoma of the uterine cervix treated by x-rays and radium with local healing. Right parametrial invasion and involvement of deep iliac nodes with venous stasis caused severe unilateral lymphedema of right lower extremity. The confluent ulcerated nodules involving the skin on the medial aspect of the thigh later developed due to retrograde lymphatic extension downward from the pelvis. Biopsy of the skin reported as epidermoid carcinoma, grade four.

contingent on muscular movements, adequately functioning valves and absence of central obstruction, although the direction of flow is usually proximal or centralward. The direction may be reversed by occlusion of the lymph vessels due to lodgment of tumor emboli or to the blockage of lymph-nodes by cancer tissue. (Fig. 8.) Under these circumstances, the afferent lymphatic is blocked and the flow of lymph may be reversed. Subsequent emboli in the series may become piled up in this distended lymphatic, the valves of which become incompetent through distention. The resultant stagnation of lymph permits retrograde lymphatic permeation. As seen in the groin, particularly in the case of melanomas, this complication results in edema of the extremity and the rapid appearance of myriads of melanotic nodules in the subdermal lymphatics. This process may occur long after the primary tumor has been completely excised and without evidence of local recurrence. This mechanism is of extreme practical importance and

its occurrence must be avoided by the exercise of considerable judgment in the management of metastatic cancer in the groin.

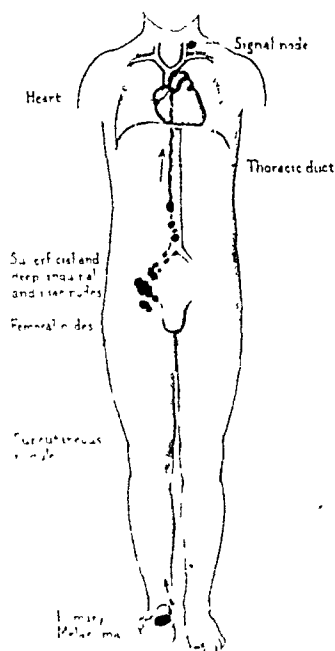


FIG. 9. Primary melanoma of sole of foot, metastatic to femoral, superficial and deep inguinal and iliac nodes. After these lymph-nodes became solidly blocked, lymphedema of the leg occurred, followed by the outcropping of numerous melanotic skin nodules in the edematous extremity.

If a groin dissection is performed before the primary cancer is removed or cured, or if a local recurrence develops at the site of the primary excision at a time following a later groin dissection, this retrograde lymphatic embolism and permeation becomes speedily evident. The initial secondary nodules to make their appearance are usually in the neighborhood of the inguinal and femoral scar where the emboli lodge in the blocked lymphatics. From this time on one may readily see the successive, more or less orderly progression in the development of these nodules subcutaneously and intracutaneously down the thigh and leg. (Fig. 9.) Bearing these facts in mind, it becomes apparent that the factor of timing a groin dissection in relation to the date of excision or treatment of the primary tumor is of major importance. If metastases in the lymph-nodes of the groin are clinically

evident at the time the primary tumor is excised, a mistake may be made in the decision as to the proper time for groin dissection. For example, if a toe is amputated for subungual melanoma and at the same operative seance a groin dissection is done, the result may be successful; but if there should be tumor cells in transit, they may lodge in the groin wound and result in a diffuse uninhibited growth which cannot be controlled. If, on the other hand, the large lymph-nodes are not removed shortly, there is the hazard of lymphatic blockage and retrograde extension down the thigh or toward the genitals, thus progressing beyond the scope of curative surgery.

#### SPREAD OF CANCERS OF THE LOWER EXTREMITY

Rouvière described in detail the lymphatic distribution of the lower extremity. The superficial lymph vessels drain the cutaneous lymphatic network through two layers of collecting vessels, a superficial lymph system in the panniculus adiposus and another more deeply situated pathway beneath the superficial fascia, extending chiefly along the vicinity of the saphenous veins. Both the upper and lower layers of this superficial system intercommunicate and occasionally there are branches which perforate the deep fascia to communicate with the deep collecting lymph vessels. The superficial lymph vessels of the genitals and lower extremity are suprafascial and do not necessarily pattern their course along the blood vessels. The deep lymphatics of the leg and thigh are smaller and usually do run along the vascular sheaths beneath the fascia.

One anomaly that occasionally occurs and is of great clinical importance is the perforation of the fascia at the level of the gluteal fold in the upper posterior thigh, wherein the lymphatics run along the sheath of the sciatic nerve to terminate in the common iliac lymph-nodes. These nodes are beyond the scope of excisional surgery and on this account certain melanomas and anaplastic carcinomas of the

gluteal skin may metastasize directly to the common iliac nodes without any intervening regional-node involvement. This accounts for certain failures to cure these cancers by a wide excision of gluteal skin, fat and fascia associated with homolateral groin dissection even when the primary and secondary tumors are thus removed *en bloc*.

**Popliteal Lymph-nodes.** The popliteal lymph-nodes are seldom involved by metastases secondary to cancers of the foot and lower leg and, therefore, are commonly ignored by surgeons in planning a method of treatment. The reason for apparent lack of interest in this regional group is because the majority of afferent lymph vessels pass directly up the leg without emptying into these particular nodes. The popliteal nodes are deeply placed in the popliteal fossa and are therefore all sub-fascial. These three to six nodes are distributed along the course of the popliteal blood vessels. Although they receive afferent lymphatics from the knee joint their practical importance in cancer diagnosis and therapy lies in the fact that they are intercalated in the paths of the lymph collecting vessels from the skin on the lateral aspect of the heel and the posterior half of the lateral border of the foot. (Fig. 10.) It is only in this location that the lymph vessels are superficial as they progress more deeply and finally become sub-fascial as they ascend the leg. There may be two or three small intercalated nodes intervening between the heel and the popliteal space; these nodes have been variously labelled as anterior tibial, posterior tibial, and tibiofibular lymph-nodes. The afferent lymph vessels from the popliteal nodes drain secondarily into the femoral lymph trunks, thence to the deep femoral and subsequently to the external iliac nodes. The anatomical facts herein related afford two valuable indications for the surgeon in planning treatment. Melanomas primary in the skin of the heel or lateral aspect of the foot should be treated not only by surgical dissection of the heel

and groin dissection but by excision of the popliteal lymph-nodes as well. Furthermore, it is possible for a melanoma or

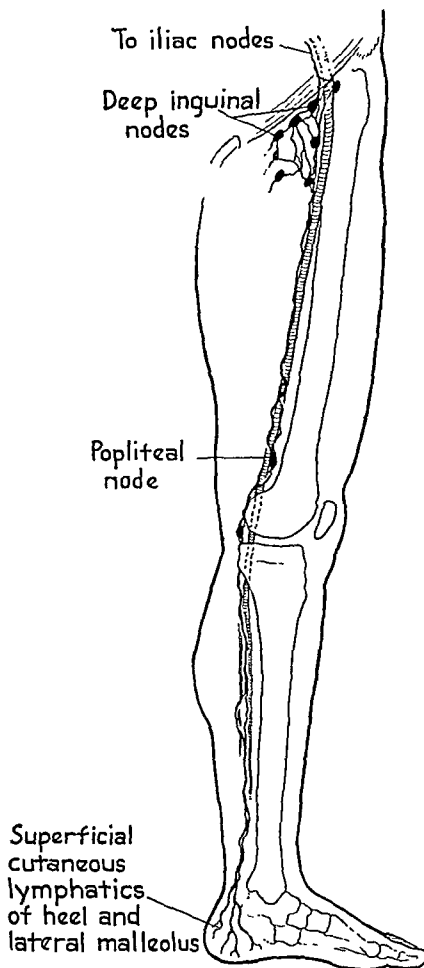


FIG. 10. The popliteal lymph-nodes are intercalated in the paths of the lymph collecting vessels from the skin on the lateral aspect of the heel and the posterior half of the lateral border of the foot. The lymph vessels from the popliteal nodes drain secondarily into the femoral lymph trunks, thence to the deep femoral and subsequently to the external iliac nodes.

anaplastic carcinoma primary in this location to metastasize through the second relay if the popliteal nodes are involved without lodgment in the superficial inguinal nodes. Reliance on palpation of these nodes to determine the presence or absence of metastases in the groin would give a false assurance of safety. Only when the deep nodes are of sufficient size to be palpable could the surgeon be aware of their participation in the extension of the



tumor. On this account, it becomes imperative for the radical deep groin dissection to follow in the course of treatment of

superficial inguinal lymph-nodes. Melanomas of the umbilicus, therefore, metastasize to the lymph-nodes of the groin

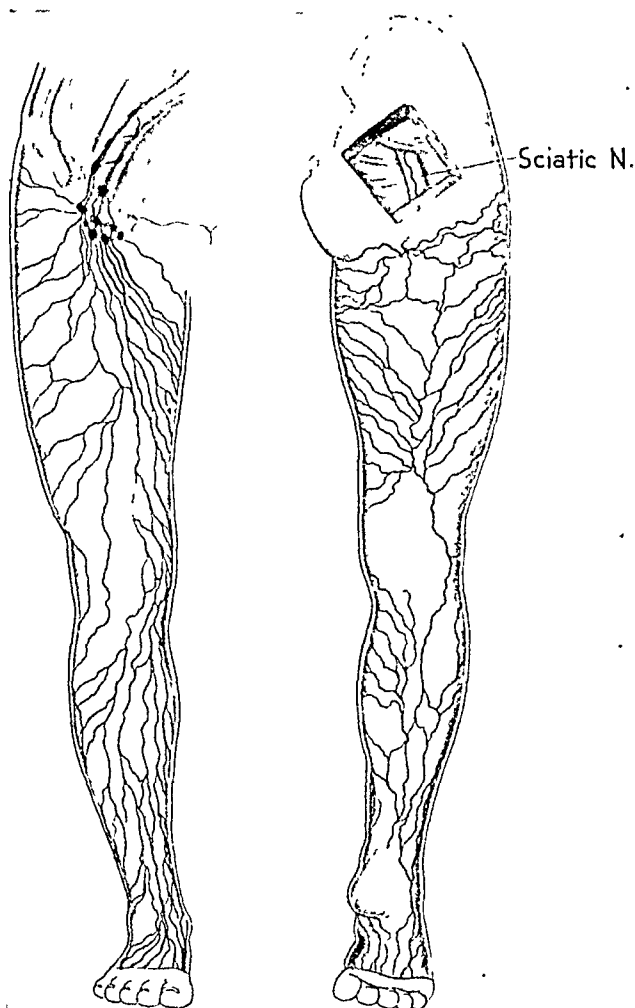


FIG. 11. Superficial lymphatic networks draining the lower extremity. Lymph vessels occasionally accompany the sciatic nerve and permit direct metastasis from gluteal skin to the common iliac lymph-nodes.

all melanomas of the heel, particularly those which metastasize to the popliteal lymph-nodes.

#### SPREAD OF CANCERS OF THE ABDOMINAL WALL AND GLUTEAL REGION

Rouviere and Tobias pointed out that the lymphatics of the supra- and infra-umbilical regions do not communicate except by very small lymphatic capillaries. The integument of the infra-umbilical region and of the umbilicus proper drains through lymphatics terminating in the

rather than to the axillary lymph-nodes. It is also possible for melanomas of the umbilicus to perforate the deep fascia and spread by metastasis through the falsiform ligament to lymph-nodes in the hilum of the liver. Radical groin dissection for melanomas and epitheliomas of the abdominal wall and umbilicus should include wide dissection of the subcutaneous fat and superficial fascia, because there are numerous lymph nodules intercalated along the course of these anterior abdominal lymphatics superior to the inguinal ligament.

One possibility which should be borne in mind by the examining physician is the occasional metastatic involvement of a lymph-node in the eleventh intercostal space posteriorly, where one of the posterior lymphatic vessels terminates. This node must reach a relatively large size and cause pain before it is usually detectable.

Although the skin of the gluteal region is drained by lymphatics which empty into the superficial inguinal lymph-nodes, the possibility has already been mentioned of occasional metastasis to the common iliac nodes by means of lymph vessels accompanying the sciatic nerve. (Fig. 11.)

#### SPREAD OF CANCERS OF THE PERI-ANAL AND PERINEAL REGIONS

Melanomas and epitheliomas of the perianal and perineal regions also metastasize into the medial superficial inguinal lymph-nodes, more commonly those of the inferomedial group. The surgeon who treats tumors in this location must be aware of the fact that the cutaneous lymphatics on both sides of the perineum intercommunicate with each other extensively along the entire median raphe and on this account there is every likelihood that the metastases, if they do occur, will be bilateral. If only one group of lymph-nodes is involved, the dissection should nevertheless be bilateral, under which circumstances the involved side may require a radical groin dissection and the clinically uninvolved side necessitate only a superficial dissection without extension above the inguinal ligament into the pelvis. By this conservatism, both groins may be dissected at the same operation.

#### SPREAD OF CANCERS OF THE PENIS

The surgeon who treats cancer of this organ should modify the character of the groin dissection based on the portion of the penis involved by the cancer. For example, if the cutaneous envelope of the body of the penis together with the prepuce is involved, the first focus of metastatic deposit is in the superficial inguinal lymph-

nodes (superomedial group) and the groin dissection in some instances might be of superficial character without extension

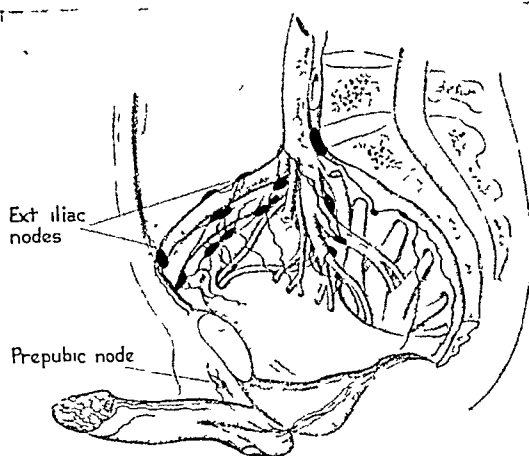


FIG. 12. The prepuce and cutaneous envelope of the body of the penis terminate in the superficial inguinal lymph-nodes. The lymphatics of the glans penis may also extend directly into the external iliac or hypogastric lymph-nodes without intervening stops.

above the inguinal ligaments. If metastases do occur even though palpable only unilaterally, a bilateral dissection should nevertheless be done because the collecting trunks at the root of the organ may separate and run either to the right or left side. Inasmuch as practically all cancers of this organ are infected, the mere presence of enlarged, palpable nodes in one or both groins does not necessarily indicate the presence of tumor metastases, as has been proved by later microscopical study. Aspiration biopsy of these enlarged lymph-nodes may show the presence of metastatic cancer, but a negative report for cancer by this method is not conclusive and the surgeon must remain alert as to the possibilities of cancer being present. The successful treatment of the primary lesion may lead to subsidence in the size of the inguinal nodes to the point of normalcy and some urologic surgeons prefer to accept this condition without surgical interference until more definite evidence of metastases appears.

If the glans is involved, the situation is infinitely more serious because the lymphatics in this region may terminate not

only in the superficial lymph-nodes but directly as well into the deep inguinal nodes and sometimes into the external

clulsion that this is one of the most dangerous locations in which cancer may occur. Successful end results in the treatment for

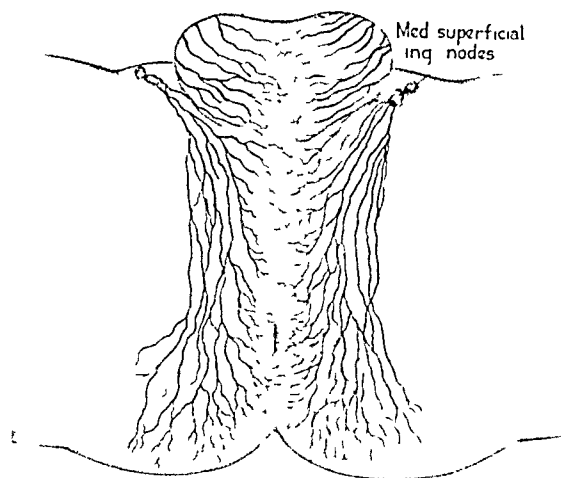


FIG. 13. The remarkable abundance of the lymphatic network throughout the scrotal skin. Observe the free anastomosis across the midline, which accounts for the necessity of bilateral groin dissections for cancers originating in the scrotal skin.

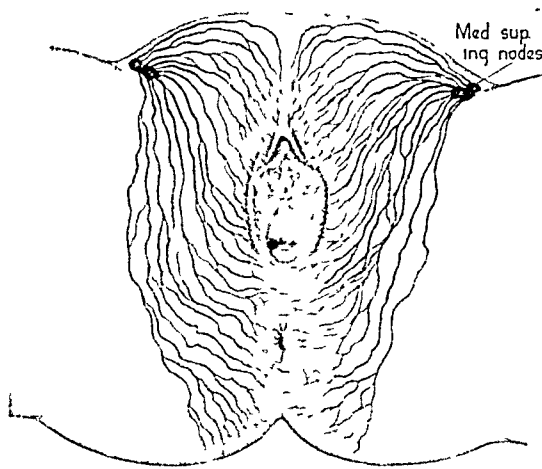


FIG. 14. The lymphatic drainage of the vulva (external to the hymen) is bilateral into the medial superficial inguinal lymph-nodes.

iliac or hypogastric nodes without intervening stops. (Fig. 12.) Therefore, in the case of malignant melanomas and epitheliomas of the glans penis or glans clitoridis, one must suspect the possible presence of metastases to these deeper lymph-nodes even in the pelvis, without the intervention of superficial lymph-node involvement and must guide one's surgical procedure accordingly.

The second anatomical fact which influences the choice of procedure is the existence of a small group of two or three prepubic lymph-nodes which are situated in the midst of the presymphyseal lymphatic plexus which drains the lymphatics of the glans and in turn empties into the external iliac lymph-nodes without a relay into the superficial inguinal nodes. Bearing these facts in mind, the surgeon has good theoretical reasons at least for extending the groin dissection above the inguinal ligament if the primary cancer involves the glans penis or glans clitoridis.

#### SPREAD OF CANCERS OF THE SCROTUM

A review of the end results of cancers of the scrotum leads to the astounding con-

clusion that this is one of the most dangerous locations in which cancer may occur. Successful end results in the treatment for epitheliomas of even low-grade malignancy are notoriously rare and if conservative excision only is employed practically no cures are ever obtained in the case of malignant melanoma. The explanation of this tragic picture is the remarkable abundance of the lymphatic network throughout the scrotal skin. The collecting lymph vessels originate along the median raphe and anastomose freely with those of the opposite side. (Fig. 13.) On this account the metastases are nearly always bilateral, and accordingly bilateral groin dissections are indicated. The local treatment of cancer of the scrotal skin must necessitate an almost complete removal of this skin *en bloc* with the inguinal lymph-nodes in order to affect a complete ablation of the disease. It should be emphasized again that the lymphatics of the scrotal skin anastomose freely with those of the penis anteriorly and those of the perineum posteriorly. Therefore, a wide surgical removal of the skin should be done.

#### SPREAD OF CANCERS OF THE EXTERNAL FEMALE GENITALS

The lymphatics of the clitoris have the same distribution as those of the penis which have been previously considered and

the same method of procedure should be followed in their treatment.

**Vagina.** Although it has been stated in many texts on gynecology that cancers in the outer third of the vagina behave as do those of the vulva, this definition is not entirely accurate. It is the hymen which is the definite boundary line; the mucous membrane of the vagina internal to this structure drains through its lymphatic network into the deep pelvis lymph-nodes and, therefore, is not concerned in this discussion. The hymen, vestibule and fourchette all drain into the inguinal lymph-nodes and the metastases thereto are treated by the methods previously described.

**Vulva.** The lymphatic network of the vulva is extraordinarily copious and there is such intimate anastomosis with the opposite side that metastases may readily occur bilaterally or even contralaterally. (Fig. 14.) All epitheliomas or melanomas of the vulva should be suspected of metastasizing to the right and left inguinal groups of lymph-nodes. The method of groin dissection therefore should be bilateral. All of these lymphatics terminate in the superomedial group of superficial lymph-nodes. If a radical vulvectomy is done in one or two stages in the absence of clinical evidence of metastases to the nodes, the dissection may be limited to the superficial, deep inguinal and retrofemoral groups without removing the external iliac nodes above the inguinal ligament. If, however, one group of lymph-nodes is found to contain metastatic cancer, the dissection on that side should extend superiorly in the radical manner. (Fig. 15.)

#### END RESULTS

The end results do not represent what could be accomplished if the present method of treatment was consistently followed. In years past, the operative procedures were frequently superficial and incomplete. In a cancer institute such as the Memorial Hospital, the percentage of advanced cases or those of borderline operability is much greater than naturally oc-

curs in a general hospital. Preliminary irradiation of the groins, now deemed not only unnecessary but harmful, caused

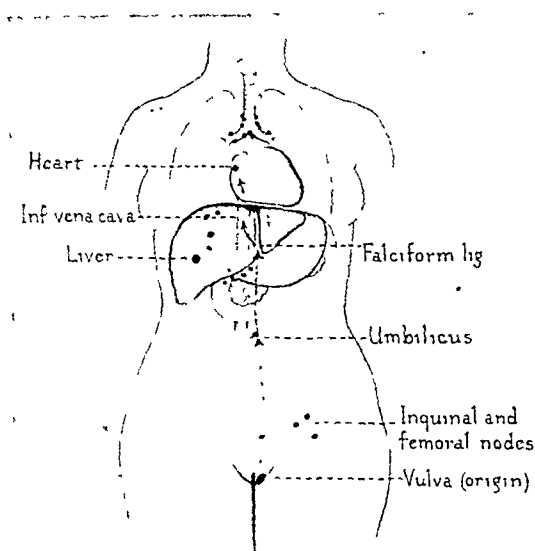


FIG. 15. Melanoma of the vulva metastatic to the inguinal and femoral lymph-nodes in a stage technically operable, were it not for other metastases to small intercalated nodes situated subcutaneously between umbilicus and vulva. Secondary melanotic nodule in umbilicus, thence metastasis via the falciform ligament to the portal fissure of the liver, with later involvement of liver, heart and bronchial lymph-nodes.

procrastination in the institution of proper surgical treatment.

Taussig performed nineteen vulvectomies and bilateral groin dissections for cancer with the following results: Twelve of these patients (63 per cent) were living and well for five years; thirteen of nineteen patients had metastasis to lymph-nodes in the groin and of this group, 65 per cent remained free of recurrence.

Daland and Holmes had only three patients (9 per cent) of thirty-five with malignant melanoma who had regional metastases and survived five years without recurrence. Twelve or 25 per cent of their forty-seven patients with melanoma without metastases to regional nodes survived five years without recurrence.

Of 267 patients with melanomas of all locations treated at the Memorial Hospital more than five years ago, thirty-eight or 14.5 per cent were living and well at the end

TABLE I  
DATA ON 122 GROIN DISSECTIONS

Type of Primary Tumor	Sex		Groin Dissection		Age		Operative Morbidity				Metastasis in Groin Nodes		Time from First Treatment of Primary Cancer to Groin Dissection (months)			End Results							Character of Dissected Groin Nodes									
	Male	Female	Right	Left	Bilateral	Elective	Youngest	Oldest	Average	Gross Infection	Delayed Wound Healing	Hemorrhage	Pneumonia, Atelectasis, etc	Skin Grafting	Operative Mortality	Before Admission	After Admission	Earliest	Latest	Average	Recurrent Cancer in Groin	Died of Cancer		Died of Other Disease or Lost Track of	Living and Well N E D	Living with Cancer	Free of Disease					
																											1 Year	3 Years	5 Years	10 Years		
No Cases	45	24	21	24	21	7	16	71	45	8	14	2	2	15	1	36	2	0	116	15	10	29	2	12	2	8	2	1	1	6	39	
Melanoma of lower extremity						(A)	36	75	56	4	6	1	1	2		5	2	0	144	32		5	1	1						1	1	
Epithelioma of lower extremity	7	5	2	4	3		49											7														
Neurosarcoma of groin	1	1	1	1			38	57	47									3	24	15		2		1								
Rhabdomyosarcoma of groin	3	3	1	2			56			1								16														
Neurosarcoma of buttocks	1	1	1	1			62	69	65	1	1							0	2													
Rhabdomyosarcoma of abdomen or back	2	1	1	2			26	68	49	1	1							2	18	11		3		1								
Melanoma of abdomen	3	2	1	2			35	57	43	2	3							1	60	21		1		2								
Melanoma of back	3	3	1	2			20	53	40	2	2							1	58	15	2	2	1	1								
Melanoma of buttocks	4	1	3	3																												
Epithelioma of anus	1	1	1	1			67																									
Epithelioma of penis	5	5	1	2			29	66	54	1	4							3	62	18	3	2		3								
Epithelioma of scrotum	3	3					57	64	60	2	2								12	6	(B)		1	1								
Epithelioma of inguinal region	3	3					2	49	71	63	1	1						1			1		1	2								
Melanoma of inguinal region	1	1	1	1			34											30														
Melanoma of vulva	2	2	1	1			15	43	29																							
Melanoma of clitoris	2	2	1	2			1*	54	67	60	2	2																				
Epithelioma of clitoris	1	1	1	1			1	60																								
Epithelioma of vulva	35	35	4	3	28	2*	34	67	55	7	11					23	10	0	140	18	11	19	1	14	1	6	1	2	3	28	28	
Total	122	118	74	44	37	41	13		50	32	49	5	5	24	2	83	27					28	72	8	39	3	21	8	4	5		
										26%	40%	4%	20%	16%							23%											

\* Nodes do not contain cancer. Elective dissection.

A Two of the seven elective dissected groins contained metastatic melanoma.

B Two of these three patients are now living and well after secondary surgical and radiation treatment.

C Developed metastases in opposite groin.

D Lost to follow up after three years.

E No definite information on character of nodes due to overlying primary cancer. Dissection of nodes considered elective. The nodes did not contain metastatic cancer. Some bilateral dissections showed only unilateral nodal involvement.

of five years. Twelve of forty-five patients (26 per cent) with melanomas of the lower extremity were living and well. There were five ten-year cures and five five-year cures following groin dissections for metastatic cancer of various types. In the case of the forty-one bilateral groin dissections, twenty-two of the patients died and the nineteen living are short of the five-year survival period on which the criterion of cure has been generally founded. The end results in detail are summarized in Table 1.

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# THE SURGICAL TREATMENT OF PERIPHERAL EMBOLISM\*

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BY arterial embolism is meant the sudden, complete, shocking closure of a major vessel, usually previously normal, with the resultant threat to the life of the individual and the affected part. The final closure of a vessel already chronically occluded is another picture, because in such chronic closures collateral circulation channels already have been prepared. Surgical treatment of peripheral embolism until recently—and unfortunately in some places still—has been confined to major amputation, if the patient survived until demarcation was complete. Fortunately, surgical therapy has been proved sufficiently successful so that a fair percentage can be saved, not only from death, but from the previous major amputations.

In 80 per cent of embolisms, there is a left-sided heart disease, usually a rheumatic endocarditis. Willis reported that 25 per cent of those who die from heart disease have emboli. There may or may not be arterial disease present. In most instances there is some added insult to the heart, such as auricular fibrillation, a surgical operation or a severe infection. Much less frequently the embolus may arise from either the right side of the heart or the peripheral venous system. These paradoxical occurrences require a patent foramen ovale. In certain instances of arterial disease, local trauma may loosen a plaque which becomes an embolus. More frequently, such injury results in a thrombosis rather than a true embolus.

*Symptoms.* The outstanding symptoms are a sudden, sharp, shocking *pain*. This is accompanied by *tenderness*, particularly at the site and below the embolus. With this pain is a *loss of function* of the affected part

and absence of knee jerks. *Color changes* are striking. The limb becomes marble white with later a blotchy blueness, and with gangrene, a black discoloration. This discoloration may extend above the line of eventual demarcation. The *temperature* of the part changes; the extremity becomes cold. Palpation of the limb shows no arterial pulsations, the blood pressure is absent and the oscillometric readings are 0. At times there is a preliminary, smaller embolus, often unrecognized until the larger, disabling one occurs. Sometimes the embolus may only partially occlude the lumen, to be followed shortly by the complete closure and its symptom syndrome.

*The Differential Diagnosis.* Usually the diagnosis is not difficult. The history of a patient with a diseased heart, who is fibrillating, or who has had some added insult to the circulatory system, is at once suggestive. No other peripheral condition causes such a sudden change to acute prostration. The differential diagnosis between embolism and *arterial thrombosis* at times may be a problem. The patient with arterial thrombosis has a history of arterial disease, probably involving both extremities. There have been the premonitory symptoms of failing blood supply to the part for some time. Rarely does an acute thrombosis occur as the first symptom. In many instances an x-ray will show calcium deposits. In the occasional patient differentiation may not be determined until the operation time. In one patient during the last year, a diagnosis of acute embolism of the saddle type was made on the history. On opening the femoral artery on either side a thrombus of a smaller caliber than the vessel lumen was found. This at once

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indicated that above the femoral site there must be a partial occlusion and probably an intimal plaque. Inability to reopen the artery completely led to a wider exploration of the iliac, after dividing the inguinal ligament. The artery was opened directly through an arterial sclerotic partial occlusion of this vessel. There had been, however, an embolus from a fibrillating heart site, which occluded the already impaired lumen. In some cases it has been possible with the use of a curette to remove this degenerative obstruction. At one time a large obstruction of this nature in the popliteal artery was cleared by a retrograde curettage. With the development of better instruments, further therapy in this line can be undertaken. *Acute thrombophlebitis* is readily differentiated. In thrombophlebitis the foot is warm, cyanotic, enlarged and the veins are distended and tender. Further examination discloses the presence of normal arterial pulsations.

*Pathology.* The usual location for an embolus is at the bifurcation of the artery. Thus we see the saddle embolus at the division of the abdominal aorta, embolus at the junction of the external iliac and hypogastric branches, at the femoral and the femoral profunda area and at the division into the anterior and posterior tibial arteries. (Fig. 1.) Accompanying thrombosis occurs in approximately one-half of the cases of embolism, but in over 90 per cent of the patients it is secondary to the embolus. It has been seen as early as two hours after the lodgement, but in our longest case no accompanying thrombosis was present. *Spasm* is a marked factor in all embolism, and according to Lund, McKetrick and Allen, is the cause for the pain. Accompanying this spasm, the collateral arteries are closed and a true ischemia of the extremity occurs. In certain instances this spasm relaxes and the collaterals relieve the condition. This known factor has been the basis of certain conservative measures of therapy. It is well to note the difference between closure of a major artery by an embolus and closure by a ligature.

Halstead, in 1924, was unable to find gangrene occurring from ligation of the subclavian artery and Mulvihill reported

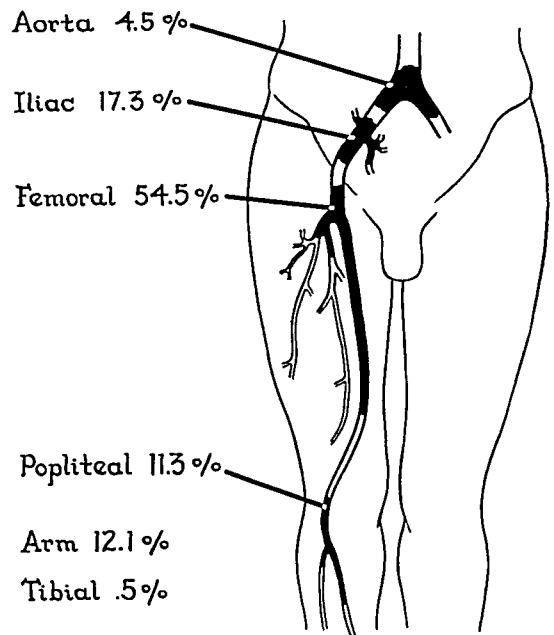


FIG. 1. Sites of embolus lodgment.

an incidence of only 14.7 per cent gangrene in sixty-seven ligations of the common iliac, external iliac and femoral arteries. Wolf found that 50 per cent of the ligations of the common iliac artery resulted in gangrene, while only 15 per cent of the ligations of the popliteal arteries affected the circulation. In the arm a mere 5 % of the brachial artery ligations were followed by gangrene. In a ligation of an artery the collateral circulation is frequently adequate. After embolism, however, the thrombus which frequently forms, extends into collateral branches and prevents their function even if spasm can be relieved.

*Treatment.* The problem in surgical treatment is one of comparatively recent development. A. A. Abanejew performed the first exploration for peripheral embolus in 1895, but failed to locate one. Moynihan, in 1897, removed an embolus from the popliteal artery, but the patient died. In 1907, both Stewart and Doberauer removed emboli with temporary benefit, but thrombosis followed shortly thereafter. Trendelenburg's first effort on pulmonary embolism was in 1907, the patient dying of



hemorrhage on the table. In 1908 to 1909 Proust, Schussi, Murphy, Carell and Leriche all tried the operation with failure.

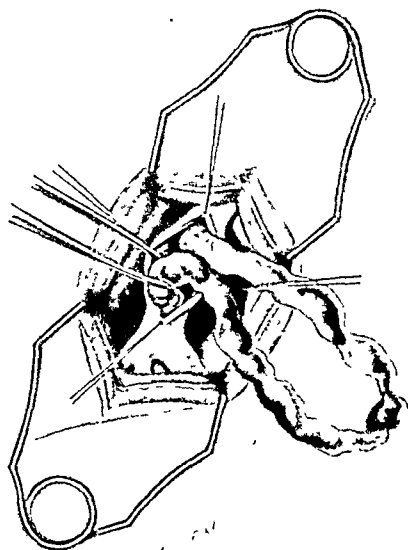


FIG. 2. Removal of thrombus accompanying embolus of the iliac artery. Thrombus is removed from the distal end first.

stricted, the previous constriction permitting and stimulating adequate collateral development. A few years ago the presenta-

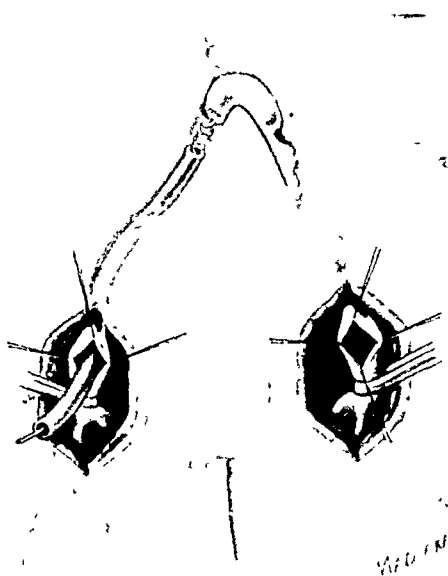


FIG. 3. Removal of embolus, using wire corkscrew protected by catheter. Protection of opposite artery to prevent embolus passage during removal.

The first successful embolectomy (Labey, in 1911) was followed shortly thereafter by Key in Sweden. From 1911 to 1925 nearly all of the operations of this type were done in the Scandinavian countries and the procedure was entirely neglected by surgeons in other countries. While there had been 150 cases in Scandinavia up to 1927, there had been less than twenty reported in the United States, Canada and England. Since that time there have been many successful operations with the Scandinavian figures of 382 embolic operations (with 22½ per cent successful) leading all the others.

It is our belief that the treatment should be surgical as soon as the diagnosis is made. We believe this notwithstanding the fact that occasionally we have seen neglected patients survive. Many such recoveries are not truly embolic. Our experiences with thrombosis in patients with vascular diseases have shown that many cases diagnosed as embolism are not true emboli of the type we are discussing, but are rather the closure of vessels previously con-

tion of the suction pressure boot by Herman and Reid led one author to state that the operation of embolectomy was no longer necessary. We have seen patients go into gangrene and death in a Paevex boot and in one instance the entire epidermis was removed by the suction apparatus. Conservative therapy, we believe, is indicated in these large emboli only until the patient reaches the operating room.

*Surgical Technic.* Local anesthesia should be the only anesthesia employed and should be utilized without the addition of adrenalin, a severe vasoconstrictor. These patients are in very poor condition and a general or spinal anesthetic often is too great a load for their circulatory system. In no other surgical procedure is gentleness so necessary. The incision for the aortic iliac or femoral embolus is made over the femoral canal just below the inguinal ligament. The vertical incision gives the best exposure. The femoral artery is isolated in the wound and a tape passed around either end of the exposed artery. After placing a fine silk stay suture at either end, the

longitudinal incision is then made in the artery. If a thrombus is present, it is removed from the distal end first, teasing it out with a smooth forceps. (Fig. 2.) With a soft rubber catheter preventing passage of clots below the incision, the proximal end is then removed. The thrombus usually breaks away from the embolus proper, leaving the embolus attached in the lumen. After some experience we have found it best to dislodge the embolus with a wire corkscrew instrument inserted up the artery. To protect the intima, I have introduced the corkscrew covered by a rubber catheter. (Fig. 3.) When the obstruction is reached, the catheter may be withdrawn. Usually, when the corkscrew is withdrawn, the embolus begins to pass. Considerable ingenuity often is necessary to remove the clot, as no one instrument will always be successful. We have borrowed many instruments from the bronchoscopic and urological departments, including the minute biopsy and flexible foreign body instruments. Suction applied to rubber or ureteral catheters may be effective in loosening the obstruction. In the femoral area it is wise to expose the profunda to ascertain its function. One must adapt changes in the technic to the pathological condition present. In one instance Carter was able manually to guide a femoral embolus into a profunda branch, re-establishing the femoral circulation without opening the arterial lumen. If there is not a free flow of spurting blood, it indicates that there is still some obstruction and further efforts are necessary to free the artery. In some instances—well illustrated by one of our patients—incision can be continued through the inguinal ligament and the hand passed retroperitoneally along the large vessels to the bifurcation. The vessel may then be manually milked until the embolus is freed. It is well to permit considerable blood spurting to be sure that no fragments or clots remain.

If there are bilateral symptoms, both femoral arteries should be exposed at once. By lightly constricting the artery of the

other side below the incision site, a possible clot passage into the opposite periphery can be prevented. Even when only one side is



FIG. 4. Embolus removed from bifurcation of aorta.

involved, careful observation of the pulsation of the other foot should be made during and after the removal of the clot for this same reason.

The arterial wound is closed with fine arterial silk on minute, curved needles. These sutures are placed so as not to enter the intima. In our early cases we frequently oversutured. It is well to remember that the pressure at any point in the arterial wall is inversely proportional to the velocity of the flow. Frequently, a single running suture is sufficient to prevent bleeding. The technic advocated by Carrel and Key of using sutures, instruments and needles coated with vaseline, has been found cumbersome and unnecessary. The needles slip and the fineness of technic required is frequently sacrificed. Irrigation of the artery at the operation with 25 per cent heparin solution is a recent and helpful addition to the technique and probably prevents some immediate thromboses. (Figs. 4 and 5.)

#### AFTER-CARE

After-care is most important and certain points should be stressed:

1. *The Use of Heparin.* Heparinization has been found valuable in preventing

clotting and while we believe that many of the postoperative thromboses at the operative site are technical errors, we are of the

moved and the patient recovered. This is an indication of what can be done in certain instances.

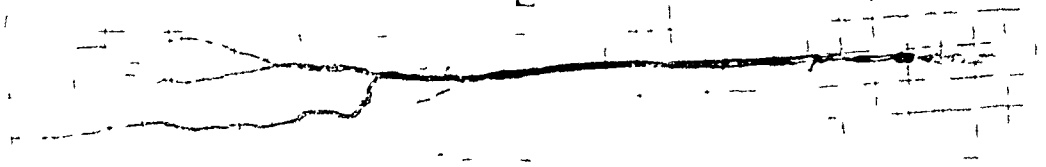


FIG 5. Embolus with thrombosis of entire artery. Thirty-three inch thrombus removed in one piece. Note thrombosis of the anastomotic branches.

opinion that heparin is indicated. It is given to maintain the clotting level three times below normal. When the cardiac status does not permit continuous intravenous drip, 5 cc. can be given intravenously every two hours, with constant testing of the clotting time.

2. *Care of the Limb.* Circulation must be carefully guarded and skin breaks and pressure areas prevented. A soft cotton combine is placed on the heel and the foot wrapped in cotton for warmth and protection. A temperature of from 92° to 96°F. has been found ideal and safely prevents burns. The leg should *not* be elevated, but the use of an oscillating bed, with its gentle arterial massage, is helpful. Unless the cardiac condition prevents their use, anti-spasmodic drugs are useful at this stage. Papaverin or eupaverine are helpful drugs. Spasmalgin, a drug combining the smooth muscle dilators, atropine, pantopon and papaverin, may be used as often as every two hours, either intravenously or intramuscularly. Whiskey, an excellent vasodilator, is well tolerated and usually welcomed by the patient. It should be remembered that other emboli may occur and if so, re-operation is indicated. One instance is reported by Macfarlane in which an embolus was removed from the right leg, with a second embolus removed from the left leg the next day. This was followed by a third embolus in the first leg at the end of the week, which was also surgically re-

3. *Lumbar sympathetic nerve block* with the introduction of 2 per cent novocaine into the lumbar sympathetics and consequent collateral dilatation and relaxation of spasms, is most helpful at this stage.

It has been proved that conservative measures are unsuccessful. Lund describes twenty-nine patients in whom there was no operation. Twenty-four died in the hospital and six survived, one-half of which lost their legs—an 8 per cent success in contrast to twenty operated cases in which nine patients died and in which there was a 35 per cent success. Similar reports have been made by McMaster, dePemberton, Nyström and Key, while Danzis reported that 87 per cent of the patients not operated upon were dead in a fortnight and all the rest had a major amputation.

In analyzing the patients seen in our own institution, records were reviewed from 1930 to 1940. This review was complicated by the fact that differential diagnosis between embolus and thrombosis was frequently not clear, and by the fact that the fatal complication of embolism frequently was not listed in the diagnosis, the cardiac status being considered primary.

Twenty-six patients were listed, of which twelve were operated upon and five survived—a percentage of 41.6 per cent. Of those who survived without operation, all lost their limbs. Again the possible error in diagnosis of many of this latter group must be emphasized. Personal observations have

been made on sixteen patients with true emboli, twelve of whom have been operated upon and four of whom were not operated upon. Dr. Franklin Carter, of the Post-Graduate Hospital, has had seven such patients, several of whom I have also observed. Of the total patients operated upon thirteen have had the circulation restored. While the percentage of patients living today after this procedure is only 23 per cent, this figure cannot be taken as a true one for embolectomy success. The operative success is actually 61.5 per cent. One must recognize that if the embolectomy restores the circulation, it has been successful. Embolectomy can not be expected to prevent death from an advanced heart lesion or to prevent other phenomena. Patients who die, do not die from the embolectomy, but they die from the lesion causing the embolus. They more frequently die from the gangrene that usually results, or the operation for it, if embolectomy is not performed. This has been statistically proved by many authors. Five patients who were not operated upon in my observation developed gangrene and died.

One other point worth mentioning is that if the patient with an embolus survives and does not have a major amputation, he is a permanent vascular cripple. One patient seen in the clinic in the last three months had such a spontaneous recovery, but now has zero oscillometric readings and such inadequate collaterals that amputation most likely will be necessary. In considering mortality statistics, one is frequently discouraged by the low percentage of patients alive after five years. Were this same discouraging outlook carried to the field of brain surgery or cancer surgery, many patients now cured of lesions would be dead.

The end results in the embolectomies in Sweden showed that one-quarter die in one year, one-half are dead in three years, one-third are alive in five years and one-eighth are alive in ten years. The graph is practically identical with that of those living after excellent surgical and x-ray therapy

for cancer of the breast. This seems sufficient answer to those surgeons who have stated that the operation is useless, because of the poor risk of the patient group. Certainly no one would advise against operation for cancer of the breast merely because only one-eighth of the patients will survive ten years.

To illustrate what can be accomplished in an apparently hopeless state, I will briefly record experiences with one patient. The removal of a large saddle embolus sixty hours after its lodgement, with survival and complete restoration of circulation in one limb and in the other to the knee is of interest and contrasts with the usual result:

A thirty-nine-year old Baptist minister had a coronary embolism on June 16, 1940. He was treated conservatively with morphine and, after recovering from the acute attack, was transferred by ambulance to a nursing home on June 19, 1940. On June 22, 1940, at 9 A.M. in the morning, he felt numbness and pain in both legs from the hips down. The legs were rubbed and treated with camphor and that afternoon he had a diathermy treatment in both legs. The right leg became severely painful thereafter. No physician saw him that day. The following day the legs were mottled, especially the right one. He was treated by repeated large doses of morphine. On the following day, June 24, there was such severe pain in both legs that the patient could no longer stand it. He was then removed to a hospital. The legs were mottled and the right leg from the midtibial area was black. Both extremities were cold from the hips down and there was a bluish discoloration extending to the crest of the ilium. There was no movement possible in either limb. Oscillometric readings, taken on June 24, were:

- 0 in the left foot; the right foot was necrotic
- 0 in both calves
- 0 in both thighs

No pulsating vessels could be felt and with a high temperature, the patient appeared to be in extremis.

Operative intervention, which ordinarily would have been refused at this late stage, was undertaken because of the attending physician's and the family's insistence and because some thought that the patient's profession gave him a better chance.

Under local anesthesia both femoral arteries were exposed and opened just below the inguinal ligaments. The arteries were empty. The right artery was explored first and many clots removed. A corkscrew, formed from silver wire, was introduced and turned into a hard fibrotic mass at the bifurcation of the abdominal aorta. The embolus was removed in sections and with considerable difficulty. A fairly adequate arterial flow then passed down the femoral artery. On investigating the left femoral artery, many more clots than on the opposite side were found. In spite of several attempts, the embolus could not be dislodged on the left side with the corkscrew, a probe or the suction catheter. The incision was extended and the hand passed retroperitoneally up to the bifurcation in the aorta. With considerable difficulty the embolus was then dislodged and milked distally with the fingers. Following this there was a projection of blood out of the femoral artery of entirely normal force. The incisions in the arteries were then closed and both wounds sutured without drainage.

At once there was improvement in the color of the left leg and foot, and later an improvement in the right leg to the midtibial area. Popliteal arterial pulsation in the left side was present at once and in a few days the dorsalis pedis could be felt. Popliteal pulsation on the right side returned at the same time. From a moribund state the patient improved and within three weeks was sitting up in bed.

The right foot and lower leg demarcated at the tibial area and on July 9, 1940, the patient was transferred to New York Post-Graduate Hospital and on July 17, amputation of the right leg was performed. Progress from that time surgically was satisfactory. There was an improvement of the electrocardiographic readings of the coronary thrombosis. On September 1, 1940, the patient had a small pulmonary embolism with resulting consolidation in the left lower lobe. He recovered from this satisfactorily and was discharged on September 27, 1940.

The successful operation on a patient who was obviously dying of his disease is

reported because we know in our experience and feel certain in others, that many apparently hopeless patients have been permitted to die when they might have been saved. We do not expect that many patients as advanced as this can be aided, but one such patient makes the attempt with all worth while.

It appears that the right side closed off earlier than the left, perhaps with an additional tibial embolus. The mottling of the left side indicated a beginning arterial failure on the day of the embolus. Collaterals were probably helpful until the next day, when apparently these likewise failed. A readjustment in the length of time after a lodgment in which surgical intervention may be tried, seems indicated. While our clinic had followed the accepted routine of surgical intervention only if the patient were seen within twelve hours of the occurrence of the embolus, this patient indicates that the arbitrary time limit can be successfully modified in most instances. This procedure will be followed in the future with reversion to the principle so aptly outlined by Sir William Osler, "that no person should be permitted to die of one disease merely because he has another."

#### SUMMARY

1. The symptoms and differential diagnosis of acute arterial embolism are described.
2. Surgical treatment is preferred to conservative treatment.
3. Surgical technic and after-care are detailed.
4. Experience with twenty-six patients and personal observations on sixteen are described.
5. The case history of a patient on whom embolectomy was performed sixty hours after the lodgment, with recovery, is presented.

# THE EFFECT OF PECTIN AND NICKEL PECTINATE ON THE HEALING OF GRANULATING WOUNDS IN ALBINO RATS\*

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## INTRODUCTION

DURING the last ten years the medical journals have contained a number of reports of the beneficial effects of certain pectin preparations on the healing of external wounds. There has been general agreement that wounds so treated, healed more rapidly, remained clean and that the scar tissue was smoother than when metal pectinates were not used. The work reported in this paper was begun several years ago for the purpose of studying the progress of healing of granulating wounds and, if possible, to obtain some light on the factors which contribute to the favorable results.

It was thought that the effect of the pectinates on tissue growth might be shown more clearly on wounds uncontaminated by infection and since rats are not easily infected they were selected for the purpose. Histological and bacteriological studies were run concurrently and the rate of closure, appearance of the scab, time of crust shedding and smoothness of the scar tissue were used as the criteria for comparison of treated and untreated wounds.

## MACROSCOPIC STUDY

The metal pectinates studied were those of silver, nickel, cobalt and copper, and checks were also run with pure pectin. At first, solutions of the metal pectinates containing 20 mEq. of each metal in 100

mil. were used. When qualitative bacteriological studies showed that these solutions had very little effect on the growth of *Staphylococcus aureus* more concentrated solutions were used. After considerable preliminary work it was finally decided to limit this study to the effects of first, a gel containing 5 Gm. of pure pectin in 100 mil. of water and second of a nickel pectinate gel containing 0.032 per cent nickel since this concentration of the nickel seemed to produce the most favorable effect on the healing of wounds. Higher concentrations of nickel seemed to be irritating.

Eighty-three rats of approximately the same age and size were used in the complete study. The hair was removed from the rumps by use of a depilatory and the skin was cleaned with soapy water. Two identical wounds (4 by 10 mm.) were made by cutting through the fascia with a double blade scalpel. The patch of skin was lifted off with forceps. The wound on the right side was treated with the pectin preparation and the one on the left was untreated. Observations were made twice a day at which time fresh gel and bandages were applied. Treatment was usually continued for four days. Figure 1 shows a series of photographs of a single rat at various stages of the healing process. These results are typical. A more rapid diminution in the size of the treated wounds, unaccompanied by any puckering of the surrounding tissue is clearly shown.

\* From Wellesley College and The Massachusetts General Hospital.

Table 1 shows the results obtained with various pectin preparations. Using the criteria for comparison previously men-

The fact that pectin and nickel pectinate produced almost the same beneficial effect is a matter of interest. The more favorable

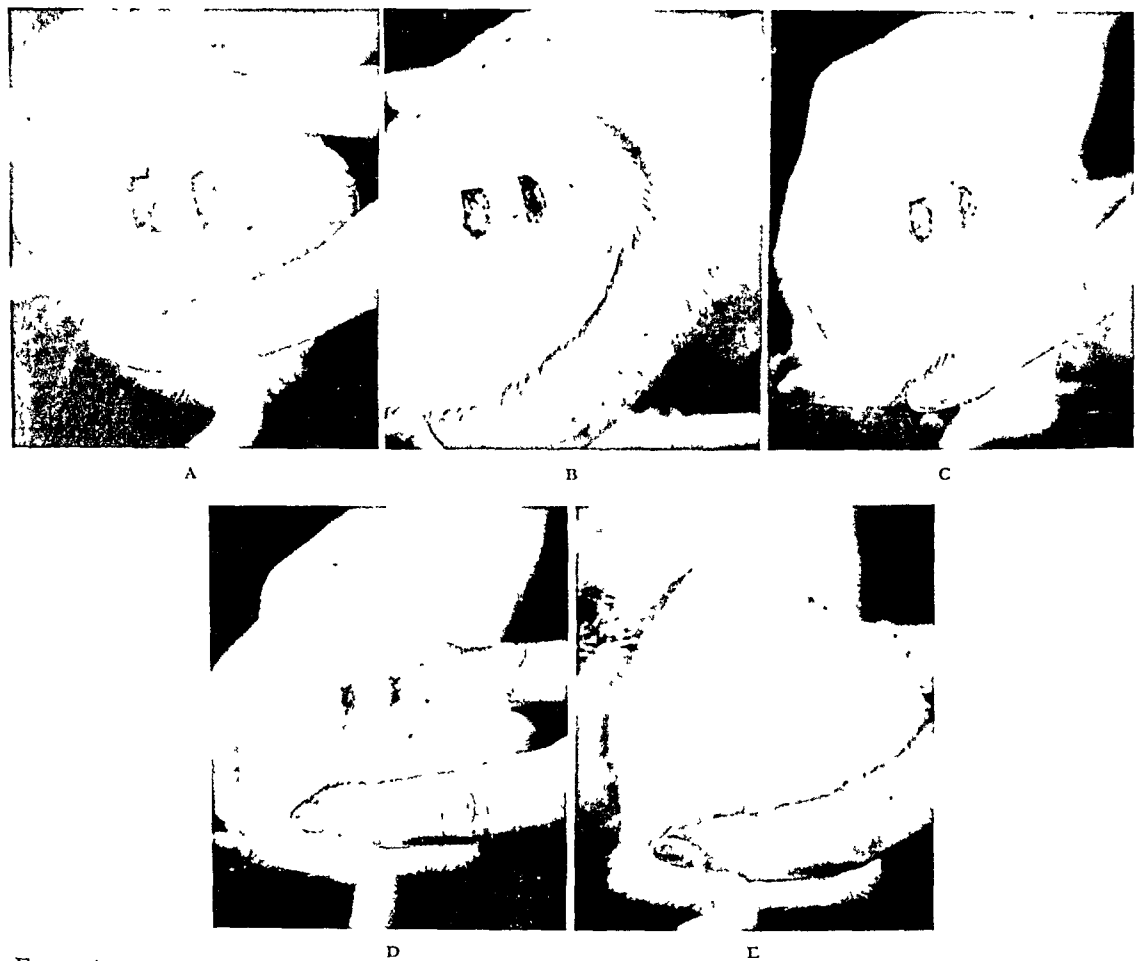


FIG. 1. Appearance of wounds on the rump of the rat in which the right side has been treated with 0.032 per cent nickel pectinate and the left side untreated. A, immediately after operation; B, C, D, E wounds of two, three, five, and eleven days after the operation.

tioned, 85 per cent of the wounds treated with pectin or nickel pectinate showed better healing than untreated wounds.

TABLE 1  
SHOWING THE EFFECT OF PECTIN TREATMENT ON THE  
HEALING OF WOUNDS IN RATS

Pectinates	Total No of Animals	No. Showing Improved Healing on Treated Side	No Showing Improved Healing on Untreated Side	No Difference in Treated and Untreated Side
Nickel pectinate containing				
0.018% Ni ..	10	8	1	1
0.032% Ni ..	13	11	1	1
0.048% Ni ..	4	0	4	0
5% pectin ..	13	11	2	0

action of nickel pectinate over plain pectin has been mentioned by several investigators, but our results with uninfected wounds do not give evidence of this. It is true, however, that the bactericidal action of the former is greater; and if the rat wounds had been infected, more marked differences in the effect of the nickel pectinate might have been shown.

HISTOLOGICAL STUDY

Tissue sections were taken from the treated and untreated wounds at 24, 72, 96, 120 and 160 hours after operation. Five animals were used for each period. The sections were fixed in Bouin's picro-formol-

acetic fixative or Zenker's sublimate bichromate mixture. They were embedded in paraffin, cut at  $7\ \mu$  and stained with Mallory's triple stain for connective tissue or in Delafield's hematoxylin and eosin. Photographs of different but comparable animals, taken at the time the tissue sections were removed, made it possible to follow simultaneously the progress of cell proliferation and wound closure. Figure 2 shows microphotographs of tissue sections taken from typical animals eleven days after the operation when healing was complete. There is evidence that pectinates have a deleterious effect on the epithelial layer. However, in the wounds treated with pectinates granulation tissue filled in faster and was more abundant and more vascular. These results substantiate an observation made by Thompkins et al.,<sup>3</sup> who reported that pectin seemed to inhibit epithelization, but stimulated rapid growth of highly vascular granulation tissue. Because of the apparent retarding effect on epithelization, they suggested the use of pectin only until the wound filled in to a certain degree after which other treatment should be used.

Sections taken earlier in the healing process gave some indication that degeneration of epithelium and inflammation of cells surrounding the wounds are less marked in the wounds treated with nickel pectinate than in those treated with plain pectin. Myers and Rouse<sup>1</sup> have suggested that nickel may act catalytically in hastening the healing process.

Another important factor in the more rapid closure of small wounds treated with these gels is the cohesive force of pectin as it dries and shrinks, thus pulling the cut edges together. This effect would be of little importance, however, in large granulating wounds.

Several investigators have reported that pectin decreases the clotting time of blood and since this might be a factor in the healing of wounds treated with pectin, a brief study was made of the clotting time of rat blood. The technic used was rather crude but the results were clear cut.

Pectin and agar compounds of equal consistency were spread on chemically clean microscope slides and the end of the rat's

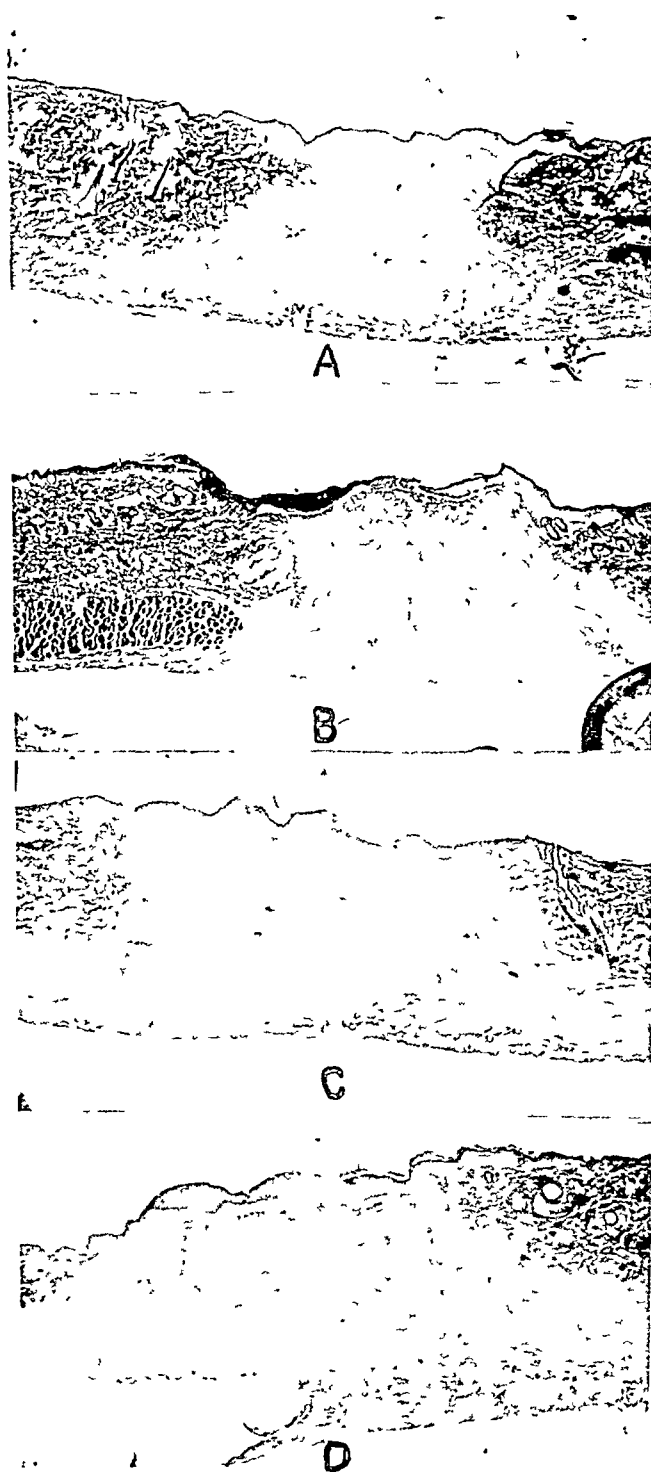


FIG. 2. Photomicrographs of tissue sections taken from scars eleven days after operation. A, rat 30, untreated side; B, rat 30, side treated with 5 per cent pectin; C, rat 24, untreated side; D, rat 24, side treated with .032 per cent nickel pectinate. Note the appearance of the epithelial layer in B and D.



tail was cut off. Three drops of blood from the freely bleeding wound were dropped onto the smears on the slides. Clotting was said to have occurred when a steel needle could pick up the entire blood mass as a soft clot. The average clotting time in minutes for each preparation is shown in Table II.

TABLE II  
SHOWING THE EFFECT OF PECTIN AND OF AGAR ON THE  
CLOTING TIME OF BLOOD OF THE RAT

Rat Num- ber	Time in Minutes for Blood to Clot When Treated with				
	Nothing in Contact with Glass	0.032 % Ni Pectinate	5 % Pectin	0.5 % Agar	1 % Galactu- ronic Acid in 0.5 % Agar
75	6	11	7	7	15
72	7	13.5	11	7	15
79	6	11	6	6	28
80	10	12	10	10	55 no clot
76	5	18	12	..	55 no clot

The results show that the pectin preparations instead of decreasing the clotting time as reported by Violle and Saint-Rat,<sup>3</sup> actually increase the clotting time of rat blood. These authors suggested<sup>3</sup> that the galacturonic acid portion of the pectin complex was responsible for increasing the speed of clotting, but in this study the greatest retardation was produced by galacturonic acid in agar. These results are in agreement with Thompkins et al.<sup>2</sup> who could observe no evidence of any marked hemostatic action of nickel pectinate when applied to external wounds of man. If these pectin gels have an antihemostatic effect, they might produce an unfavorable action if the wounds were bleeding freely. Since skin wounds of rats show slight or no hemorrhage, no such effect was observed in this study.

#### BACTERIOLOGICAL STUDY

While these experiments on rats were in progress, all of the pectin preparations used were investigated bacteriologically. Qualitative and quantitative methods were employed and the organisms used were two

strains of *Staphylococcus aureus* (A and B) which had recently been isolated from cases of urinary infection.

The following qualitative bacteriological procedure was used. The liquid nutrient agar medium was inoculated with twenty-four-hour nutrient broth culture of the organism using 1 mil. of culture for 50 mil. of agar. As soon as the agar had coagulated in the plates, 0.05 mil. of the pectin or metal pectinate gel was placed on the center of the agar film. The plates were incubated at 37°C. for twenty-four hours. The diameter of the clear zone around the drop of gel, free from bacterial colonies, was measured. In Table III the results with the different pectin gels are tabulated. Although silver pectinate was thus shown to be the most effective in inhibiting the growth of *Staphylococcus aureus*, it was not used in this study because its effect on wound healing seemed to be too destructive in character. The same deleterious results were found in less degree with copper and cobalt.

TABLE III  
EFFECT OF METAL PECTINATES ON THE GROWTH OF  
- *Staphylococcus aureus*

Strain	Pectinate	Diameter of Clear Zone, Cm.
A	Silver	1.0
A	Copper	0.5
A	Cobalt	0.5
A	Nickel	0.1
A	Bismuth	0.1
A	Pectin	0.1
B	Silver	1.1
B	Copper	0.6
B	Cobalt	0.4
B	Nickel	0.1
B	Bismuth	0.1
B	Pectin	0.1

A more thorough bacteriological study was made of nickel pectinate by the quantitative method. Nickel pectinate was dissolved by steaming in 10 mil. of double strength nutrient broth containing brom thymol blue. Sterile water was added aseptically to bring the volume to 20 mil.

The final concentrations contained 0.009, 0.015, and 0.024 per cent nickel. To a duplicate tube containing the same quantity of pectinate were inoculated at the same time and incubated in the water bath. Plate counts of the pectinate-treated and

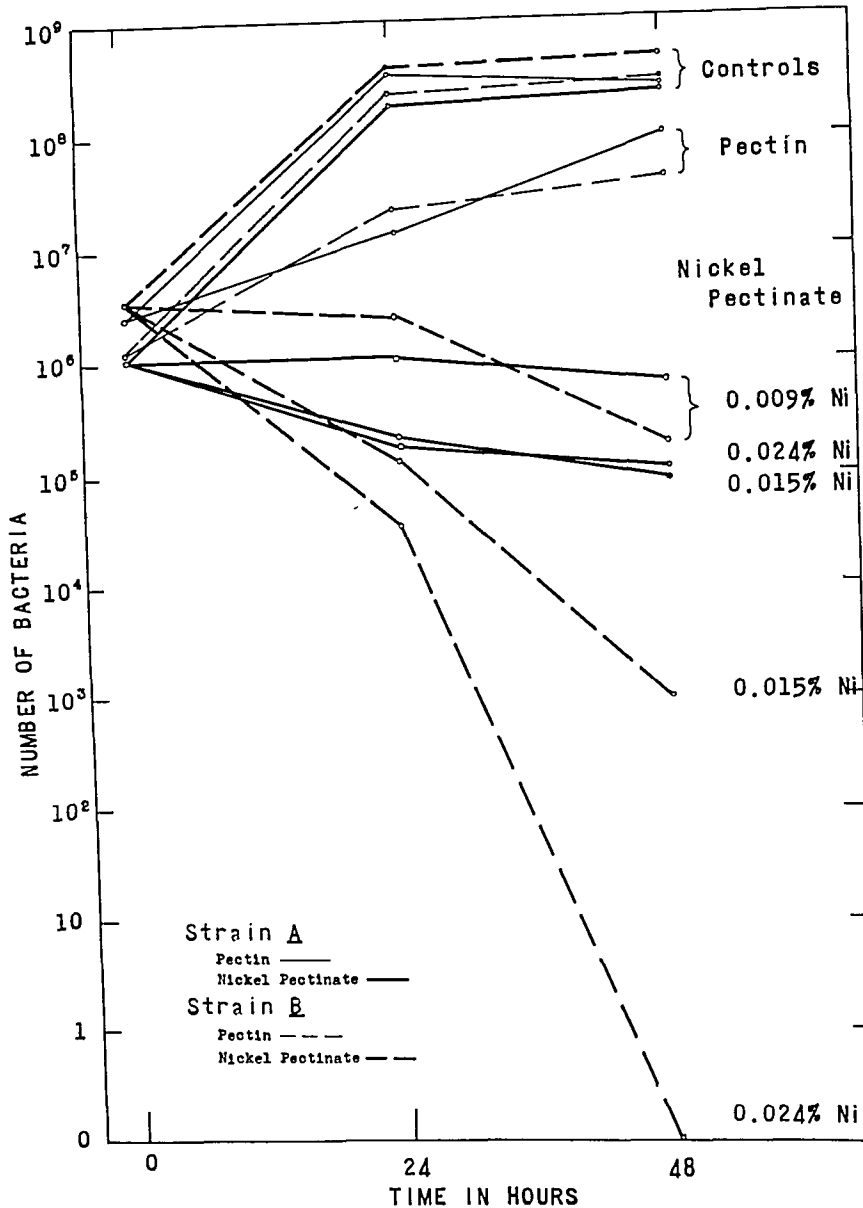


FIG. 3. The effect of pectin and nickel pectinate on the growth of two strains of *Staphylococcus aureus*.

tity of pectinate, normal sodium hydroxide was added to bring the reaction of the solution to a hydrogen ion concentration of 7.0 before diluting to 20 mil. with sterile water. Each tube was inoculated with 0.1 mil. of twenty-four-hour broth culture of the organism and stirred well. These cultures were incubated in a water bath at  $37^{\circ}\text{C}$ . for the duration of the experiment. Control cultures of nutrient broth without

untreated cultures were made on nutrient agar at twenty-four and forty-eight-hour intervals after inoculation. Counts of the initial number of organisms present in the cultures were also made. In Figure 3 the data obtained in these experiments are presented in the form of graphs.

There was no increase in the bacterial population in any of the cultures treated with nickel pectinate, whereas the control

broth culture showed the typical increase in bacterial numbers. There was a gradual diminution in the number of viable cells in the neutralized cultures while the unneutralized cultures showed a marked increase in growth of the cocci, although the populations were less than those of the control broth cultures. The unneutralized cultures with pectin contained only a few viable cocci after twenty-four hours and were sterile within forty-eight hours.

#### SUMMARY

1. When wounds made on the rumps of rats were treated with pectin and nickel pectinate gels, in 85 per cent of the cases, the rate of formation of granulation tissue was more rapid and the vascular tissue was firmer than in the untreated wounds.

2. Pectin and nickel pectinate had an adverse effect on epithelization, when treatment was continued for a prolonged period. Microscopically, there is definite evidence that the pectin preparations inhibit the formation of epithelium as shown by bleb formation, ulceration and cellular changes.

3. Bacteriological studies show that nickel pectinate gel containing 0.024 per cent nickel completely inhibits the growth of *Staphylococcus aureus* and has slight

germicide action. A 5 per cent pectin gel has an inhibiting effect on the growth of this organism but does not entirely prevent growth. Clinical work on the use of nickel pectinate on the treatment of wounds is in progress and will be reported in a later paper.

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# PERITONEAL ADHESIONS\*

## STUDIES ON THEIR PREVENTION WITH SODIUM RICINOLEATE

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THE formation of intra-abdominal adhesions, an essential process in the healing of all structures covered by peritoneum, has engaged surgeons since the advent of abdominal surgery. Only when this formation has been excessive, wherein remnants of adult fibrous tissue remain in abnormal regions, can the formation of adhesions be considered unfavorable. Cases in which these remnants disturb the functional efficiency of abdominal viscera are rather numerous and their prevention constitutes an important problem in surgery.

Hertzler<sup>1</sup> emphasizes that "healing by first intention is exactly parallel with the formation of adhesions. The formation of permanent adhesions is a condition not to be prevented but to be controlled, one to be made to take place only where we need them." Unfortunately, even under aseptic conditions, trauma of tissues remote from the site of operative apposition results in the formation of adhesions which bind structures to the abdominal wall or to each other, causing interference with normal function. It is the prevention of these adhesions that has led surgeons to attempt to assist normal healing along controlled lines. Many of these measures have been contrary to essential principles of healing. Others have been designed either to avoid the necessity of healing by care in preventing trauma, or to enhance healing by stimulation of the normal mechanism. The latter methods have been the most successful.

To prevent adhesions is to prevent healing. To control the extent of adhesions is the goal of every surgeon. Thus the problem has been approached with the thought of preventing abnormal apposition of

structures. Definite principles have been followed to attain this goal, some have proved to be harmful, some have been harmless, and a few have been beneficial. As Hertzler<sup>1</sup> states, "The idea of preventing adhesions has led to the introduction of anything that could be bent, poured or powdered with the usual result of making matters worse."

I have been able to compile the following methods employed to prevent adhesions:

- I. Avoidance of trauma to the peritoneum by
  - (1) Careful handling of tissues
  - (2) Use of rubber sheets, etc., to protect the peritoneum during operation
  - (3) Use of rubber covered clamps to compress tissues
  - (4) Avoidance of necrosis of tissues by tight ligatures
  - (5) Minimal introduction of foreign materials
- II. Operative covering of denuded areas by
  - (1) Omental grafts
  - (2) Apposition or interposition of intact omentum
  - (3) Peritoneal transplants
  - (4) Eversion of peritoneal margins into wounds in closure.
  - (5) Inversion of peritoneum to cover stumps of ligated vessels, amputated viscera, lines of anastomoses, etc.
- III. Mechanical separation of denuded areas by
  - (1) Inflation of viscera:
    - (A) Boric acid solution in the bladder

\* This article was submitted for publication by the author previous to his undertaking his present duties as Executive Officer of the Procurement and Assignment Service.

- (B) Enemas or gases in the large bowel
- (2) Interposition of
  - (A) Foreign solid or semisolid materials: 1, Cloth of catgut, fish bladder and calf peritoneum; 2, ox peritoneum (Cargile membrane); 3, oiled silk; 4, silver foil; 5, tin foil; 6, goldbeater skin; 7, lanolin-boric acid paste; 8, agar-gelatin paste; 9, acacia mucilage; 10, acacia-gelatin paste; 11, colloidion; 12, aristol powder; 13, iodoform powder
  - (B) Viscid foreign lubricants: 1, Vitreous of calf eye; 2, mucin; 3, olive oil; 4, liquid petrolatum; 5, vaseline oil (paraffin); 6, yellow vaseline; 7, humanol; 8, omental oil of ox; 9, camphorated oil; 10, lanolin; 11, Lanolin and paraffin
  - (C) Nonviscid foreign lubricants: 1, Saline solutions; 2, saline-adrenalin solutions; 3, glucose solutions; 4, magnesium sulfate solution; 5, defibrinated blood
  - (D) Gases: 1, Air; 2, oxygen
- (3) Anticoagulants (to prevent coagulation of plastic exudate)
  - (A) Hirudin
  - (B) Citrate solutions
  - (C) Ammonium oxolate solution
- (4) Digestants (to remove plastic exudate)
  - (A) Pus obtained by sterile turpentine abscess of thigh
  - (B) Pepsin-pregl iodine solution
  - (C) Peptone
  - (D) Trypsin
  - (E) Papain
- (5) Postoperative movement of structures
  - (A) Early movement of patient in bed

- (B) Massage of abdomen
- (C) Posture to eliminate apposition of operated structures
- (D) Stimulation of peristalsis by, 1, local heat to abdomen; 2, drugs
- (E) Early movement and exercise of patient out of bed

#### iv. Stimulation of the peritoneal defense mechanism

- (1) Amniotic fluid concentrate
- (2) Sodium ricinoleate

The above list serves to confirm the statement of Hertzler,<sup>1</sup> and is elaborate testimony to the inadequacy of any single measure to prevent unfavorable adhesions. Before discussing the results obtained by the above measures it is well to review briefly the processes encountered in the formation of adhesions, processes synonymous with normal healing. The majority of the following is taken from Hertzler.<sup>1</sup>

*Primary healing* (under favorable conditions, without sepsis, disturbance of coagulation, or the presence of foreign bodies or of digestive juices):

Upon the coaptation of peritoneal surfaces there is an almost immediate outpouring of a clear, structureless exudate which covers the surface. Within ten minutes fibrin is formed within this exudate. This process is completed within one hour and the exudate contracts. In three or four days this fibrinous material begins to be converted without replacement into fibrous tissue, this process being completed within six to eight days. Meanwhile large macrophage cells of the reticulo-endothelial system settle out from the peritoneal fluid onto the healing area, each cell becoming flattened and serving as an island of new endothelial covering. This process results in peritonealization of the denuded surface in seven to ten days. According to Hertzler<sup>1</sup> the peritoneum is well healed in four to seven days. This union affords a protective layer over the muscular and mucosal layers which require much longer to heal.

*Delayed or secondary healing* (under unfavorable conditions, such as hemorrhage,

interposition of foreign bodies or devitalized tissues, infection, presence of digestive juices and delay or prevention of the coagulation of blood serum):

Under these conditions coaptation is hindered or prevented by the presence of foreign bodies or devitalized tissue, the formation of fibrin is prevented by factors which prevent coagulation, or fibrin is destroyed by the action of digestive juices. Hence the processes of primary healing are delayed and another process intervenes to promote healing. This consists of the development of a granular fibrin, not a fibrillar fibrin as in primary healing. This granular fibrin forms a protective coating to limit the spread of infection. It is later absorbed, then fibrous healing takes place. In overwhelming infections or the sudden extravasation of intestinal contents into the peritoneal cavity, even this granular fibrin cannot form and a less effective attempt is made in the nature of a granular exudate which may agglutinate structures, but which is incapable of forming the temporary adhesions of granular exudate in delayed healing. Agglutinated surfaces offer little resistance to spreading infection. Granular fibrin, if successful, resists spread. Fibrillar fibrin then takes over the function of healing.

From the above it is evident that certain physiological processes are essential to healing of the peritoneum. First, an exudate must be thrown out which is capable of coagulating, thus forming granular or fibrillar fibrin. Second, removal of granular fibrin must be accomplished in order that fibrillar healing may take place. Opie<sup>2</sup> has found that lytic enzymes are elaborated by polymorphonuclear leucocytes which remove this material by digestion. Others have shown that these cells and the monocytes of the reticulo-endothelial system remove foreign material. Third, monocytes must be present which adhere to the surface of the healing area, then flatten to form new endothelium. No doubt there are other important factors, such as elements of blood serum and peri-

toneal fluid, immune substances of which little is understood. It is assumed by Steinberg<sup>3</sup> and others that the ability of the peritoneum to combat infection is a local process, not a general body immune response.

Jones and McClure<sup>4</sup> summarize a discussion of attempts to prevent adhesions as follows: "Complete solution of the problem lies in perfecting our imitations of those methods by which nature accomplishes the prevention and ablation of adhesions." We know that nature's methods include the outpouring of an exudate of blood serum, the coagulation of this serum with subsequent production of granular or fibrillar fibrin, the digestion of fibrin by lytic enzymes from polymorphonuclear leucocytes, the regeneration of endothelium by monocytes, and the elaboration of certain substances to combat bacteria and toxins.

An analysis of the methods employed to prevent adhesions shows that attempts have been made to assist nature's processes as follows: (1) The covering of denuded areas with insoluble or slowly soluble materials to confine the area of healing; (2) the hastening of coagulation of blood serum (aristol powder) or the substitution of a coagulum (acacia-gelatin, agar-gelatin, colloidion, etc.); (3) the separation of structures by lubrication with substitutes for exudate fluid (saline, glucose, dextrose, liquid petrolatum, etc.); (4) assisting or hastening of the digestion of fibrin (peptone, papain, trypsin), and (5) the loosening of temporary adhesions by early movement of structures (early exercise, stimulation of peristalsis, etc.). While there have been both favorable and unfavorable reports on the employment of these measures, the following general conclusions seem to voice the verdict of the recent literature:

*Foreign Solid or Semisolid Materials.* These have been condemned by Hertzler<sup>1</sup> as follows: "Every conceivable foreign body has been employed in the peritoneal cavity, despite the fact that foreign bodies are the most certain means of provoking

adhesions. For most of them it may be said that they brought about the very thing they were introduced to prevent. The universal rule is, that what the peritoneum cannot absorb, it walls off or dies in the attempt."

*Foreign Lubricants, Viscid.* Some of these substances have been found to be too irritating while most of them have failed to produce the desired results. Liquid petrolatum was found by Norris and Davison<sup>5</sup> to be encapsulated in multiple tumor-like masses many months after its introduction intraperitoneally. Uncertain results have been reported after the use of olive oil, vaseline and camphorated oil.

*Foreign Lubricants, Nonviscid.* These substances have served to illustrate the difficulty of retaining an isotonic or hypertonic solution intraperitoneally for a time sufficient to prevent adhesions between structures. Adrenalin was added to saline solutions by Marvel<sup>6</sup> in an attempt to delay absorption. Hypertonic solutions have been found to remain for variable periods of time, somewhat influenced by the balance of fluid between the body tissues, the blood stream and the peritoneal cavity. Indications are that hypertonic solution are rapidly rendered isotonic by osmosis and that the retention of an isotonic solution within the peritoneal cavity demands an excess of fluid within the body tissues and the blood stream if absorption is to be delayed.

*Anticoagulants.* Hertzler<sup>1</sup> states, "If the blood of an animal is made incoagulable by artificial means, such as by the use of leech extract of peptone, it prevents the formation of primary fibrin bundles, and the wounds will not heal." Pope<sup>7</sup> and Walker and Ferguson<sup>8</sup> found that sodium citrate solutions intraperitoneally were very effective in preventing adhesions, while Straus,<sup>9</sup> Sweet, Chaney and Willson<sup>10</sup> found them to be of no value. Since the coagulation of exudate is necessary to the production of fibrin it is difficult to explain good results on the basis of the prevention of coagulation.

*Digestants.* The use of digestants has been based on the findings of Opie<sup>2</sup> that polymorphonuclear leucocytes elaborate lytic enzymes which digest fibrin. The use of papain solutions has met with pronounced success in the hands of Kubota,<sup>11</sup> Ochsner and his associates,<sup>12</sup> Walton<sup>13</sup> and Yardumian and Cooper.<sup>14</sup> It is well known that the escape of digestive material from the stomach, pancreas or intestine prevents healing and frequently results in peritonitis and death from inability of the organism to wall off infection. Johnson<sup>15</sup> and his associates emphasize that the digestive action of papain and pepsin is dangerous in cases likely to develop postoperative infection, in that these materials destroy a first line of defense. Under aseptic conditions, however, papain solutions have been shown to prevent 90.89 per cent of the recurrence of adhesions in experiments conducted by Ochsner and Garside.<sup>16</sup>

*Peritoneal Stimulants.* While amniotic fluid concentrate and sodium ricinoleate are listed under this heading, it is recognized that any substance which causes an irritation to the peritoneum must be classed as a stimulant. Pfeiffer and Issaef<sup>17</sup> demonstrated in 1894 that the intraperitoneal injection of normal broth, peptone or urine so altered the local defense of the peritoneum of guinea pigs that they could subsequently withstand doses of cholera vibrio that would otherwise be fatal. Morton<sup>18</sup> found that local peritoneal immunity to hemolytic streptococci could be produced in rabbits by the injection of dextrose broth, 1 per cent sodium chloride solution and varying concentrations of glucose in water or in saline. Hermann,<sup>19</sup> Bargaen,<sup>20</sup> Judd and Waldron,<sup>21</sup> and Dixon and Bargaen<sup>22</sup> have shown that local peritoneal immunity is stimulated by the injection of killed suspensions of *Escherichia coli* and hemolytic streptococci, and in more than 1,500 cases so stimulated forty-eight hours prior to elective resection of the colon, mortality from peritonitis has been reduced 66 per cent. It is probable that much of the beneficial effect attributed to many of the

solutions introduced intraperitoneally has been due to this peritoneal stimulation by nonspecific substances. Seeley, Higgins and Mann<sup>23</sup> demonstrated that even sterile distilled water provoked an influx of 19.0 per cent polymorphonuclear neutrophils after six hours. Amniotic fluid concentrate, antiperitonitis vaccine (Bargen<sup>22</sup>) and 2.0 per cent sodium ricinoleate resulted in an influx of 36 per cent, 51 per cent, and 72 per cent, respectively, after three hours. The normal peritoneal fluid of the white rat does not contain polymorphonuclear neutrophils.

This response in the peritoneum may be referred to as stimulation. It is important that the degree of stimulation be below the level of detrimental irritation. I have found that 1.0 per cent sodium ricinoleate is well tolerated intraperitoneally by rabbits, but that 2.0 per cent will occasionally result in death. Corwin<sup>24</sup> reports the same experience. In monkeys I have tested sodium ricinoleate intraperitoneally in concentrations varying from 0.25 to 4.0 per cent and found it to be well tolerated. White rats tolerated 2.0 per cent sodium ricinoleate very well. Johnson<sup>15</sup> reports that 1.0 per cent sodium ricinoleate causes destruction of peritoneal endothelium in dogs. That 1.0 per cent sodium ricinoleate is well tolerated intraperitoneally in the human is attested to by the experience of Wangenstein<sup>25</sup> and Gillette.<sup>26</sup> Wangenstein<sup>27</sup> uses 1.0 per cent sodium ricinoleate to cleanse all mucous surfaces in gastric and intestinal anastomoses and employs 90 cc. of 1.0 per cent sodium ricinoleate in a 70 kilogram man for peritonitis. Gillette<sup>26</sup> has used 1.0 per cent sodium ricinoleate intraperitoneally in over 300 cases of peritonitis, instilling 50 cc. at twelve-hour intervals. He believes it to be of definite value.

Conflicting reports have appeared in the literature on the value of amniotic fluid concentrate in the prevention of adhesions. Johnson,<sup>28</sup> Warren,<sup>29</sup> Trusler<sup>30</sup> and Kimp-ton<sup>31</sup> report excellent results in the prevention of adhesions experimentally and clinically. Rea and Wangenstein<sup>32</sup> found

that it prevented adhesions in 70 per cent of rabbits in which the intestine had been traumatized and painted with tincture of iodine. They found that 1.0 per cent sodium ricinoleate prevented adhesions in 85 per cent of rabbits in a similar series. Lacey<sup>33</sup> reported amniotic fluid was harmless when injected intraperitoneally, that it seemed to stimulate the peritoneum to a more powerful defense action, but that it could not be depended upon to prevent adhesions. Gepfert<sup>34</sup> reported that after trauma to the bowel and stomach of dogs, repeated operations to separate adhesions resulted in the formation of fewer and less dense adhesions when amniotic fluid was used.

#### EVALUATION OF THE EFFECTS OF SODIUM RICINOLEATE INTRAPERITONEALLY

Sodium ricinoleate is a soap, the sodium salt of ricinoleic acid. Larson<sup>35</sup> and his associates have demonstrated that it has strong bactericidal, bacteriostatic and detoxifying properties, and that it is well tolerated intraperitoneally in experimental animals. Seeley, Higgins and Mann<sup>23</sup> compared the effect of 2.0 per cent sodium ricinoleate, antiperitonitis vaccine (Bargen<sup>20</sup>) and concentrated amniotic fluid when injected intraperitoneally into white rats. The total number of cells present in the peritoneal fluid and the amount of peritoneal fluid was determined at intervals with the following results: (Table 1).

Corwin<sup>24</sup> reported similar results in rabbits when he compared the effect of intraperitoneal injection of 1.0 per cent sodium ricinoleate and antiperitonitis vaccine.

Rea<sup>36</sup> reported excellent results following the use of three or four ounces of 1 per cent sodium ricinoleate intraperitoneally in cases of gross or suspected contamination.

In these studies it will be noted that sodium ricinoleate was highly effective in provoking an increase of neutrophils and monocytes and was especially effective in provoking an increase in the amount of peritoneal fluid which persisted for seven days in rats and for five days in rabbits. In



a study to determine the mechanism of this increase in peritoneal fluid, Rider<sup>37</sup> found that sodium ricinoleate behaved in solution more like a crystalloid than a colloid, that it was readily dialyzed and that it was incapable of producing an increase in its own volume on a purely osmotic basis. He concluded that the increase of fluid within the peritoneal cavity after the introduction of sodium ricinoleate was not due to purely physical effects but to some effect on secretory mechanisms.

follows: 0.25 per cent, 0.5 per cent, 1.0 per cent, 2.0 per cent, 3.0 per cent and 4.0 per cent in distilled water, 2.0 per cent in normal saline and 2.0 per cent in concentrated amniotic fluid.

Forty-eight monkeys were divided into eight groups. Intraperitoneal injections were given, each group receiving different concentrations of sodium ricinoleate as prepared above. In order to standardize the dose, it was decided to give 3 cc. of solution for each kilogram of body weight. On this

TABLE I  
INTERVAL IN HOURS AFTER INJECTION  
Cells in millions; fluid in milligrams

Solution used		Control	1	3	6	12	24	48	72	168
Amniotic fluid conc. (amfetin)	Monocytes	18.01	14.77	11.37	11.58	10.52	13.77	12.43	20.30	30.47
	Neutrophils	.08	1.22	8.72	8.50	4.96	3.65	.58	.47	.08
	Wt. of fluid	223.	546.	357.	295.	160.	194.	159.	228.	335.
Antiperitonitis vaccine (Bergen)	Monocytes	18.01	9.43	9.10	10.67	10.15	26.78	24.51	23.90	24.25
	Neutrophils	.08	1.17	13.37	9.83	7.30	8.71	2.31	.72	.20
	Wt. of fluid	223.	259.	280.	238.	190.	354.	213.	246.	257.
Sodium ricinoleate 2.0 per cent	Monocytes	18.01	11.25	8.17	15.60	11.56	30.	43.35	65.29	24.65
	Neutrophils	.08	7.12	21.53	23.76	7.45	12.15	8.75	9.11	.51
	Wt. of fluid	223.	3692.	3177.	3373.	988.	1522.	1583.	2013.	581.

Further properties of sodium ricinoleate have been evaluated by the following experiments:

#### STUDIES ON THE TOLERANCE OF SODIUM RICINOLEATE WITHIN THE PERITONEAL CAVITY OF THE MONKEY

In order to determine the effect of various concentrations of sodium ricinoleate within the peritoneal cavity of the monkey, the following experiments were conducted. Monkeys (*Pitheous mindanensis mindanensis*) were procured from plantations in the southern Philippines. They were housed in large pens with shelters and observed for three months for any evidence of mortality from disease. All were healthy and none died during the period of observation except from fighting.

A standard solution (40 per cent) of sodium ricinoleate was used for stock. A series of eight dilutions were prepared as

basis, an adult human weighing 70 kg. would receive a dose of 210 cc. Intraperitoneal injection was made by suspending the animals by their hind limbs, thus allowing the viscera to fall toward the diaphragm. The solution was introduced midway between the umbilicus and symphysis pubis. Before this method was used faulty injections frequently resulted because of movement of the animals.

Following injection, animals of each group were killed at intervals from twenty-four hours to twenty-one days. Death was produced by exsanguination following administration of a light chloroform anesthesia. A complete necropsy was carried out in each case, and particular attention was given to the degree of inflammation present and to the amount of fibrinous exudate or adhesions existing within the peritoneal cavity. Portions of the liver, kidney, spleen, small intestine and anterior

abdominal wall were fixed in formalin, sectioned and stained for histologic examination. Five control animals were killed in a similar way and similar tissue specimens were removed for comparative study.

saline than in the series injected with 2.0 per cent in distilled water. The degree of inflammation in the series injected with 2.0 per cent in concentrated amniotic fluid was approximately the same as in the series

TABLE II

Table II  
SUMMARY OF EXPERIMENTS

Experiment	Sex	Weight, Kg.	Sodium ricinoleate concentration and diluent	Ccf. of solution	Interval after injection until killed	Inflammation of peritoneal cavity	Adhesions of abdominal cavity	Comments
1	M	4.0	0.25% in dist. water	12.0	24 hours	-	-	Discarded. Injection into transverse colon
2	M	4.0	0.25% in dist. water	12.0	48 hours	+	++	Omentum adherent to small bowel
3	M	4.0	0.25% in dist. water	12.0	4 days	+	+	Necrosis of descending colon, well walled off. Faulty injection
4	M	4.0	0.25% in dist. water	12.0	7 days	0	0	Normal
5	F	2.5	0.25% in dist. water	7.5	14 days	0	0	Normal
6	F	3.5	0.25% in dist. water	10.5	21 days	0	0	Normal
7	F	4.0	0.5% in dist. water	12.0	24 hours	+	0	Mild inflammation of peritoneum
8	M	4.0	0.5% in dist. water	12.0	48 hours	+	0	Entirely normal
9	M	5.0	0.5% in dist. water	9.0	4 days	+	+	Very slight inflammation at site of injection with adhesion of omentum to belly wall this region
10	M	4.0	0.5% in dist. water	12.0	7 days	0	0	Normal
11	F	3.0	0.5% in dist. water	4.5	21 days	0	0	Normal
12	M	4.5	1.0% in dist. water	13.5	24 hours	+++	+++	Generalized fresh, loosely matted adhesions belly wall, omentum and intestines
13	F	1.5	1.0% in dist. water	4.5	48 hours	+	+	One small fresh adhesion between mesentery and cecum
14	F	2.0	1.0% in dist. water	6.0	72 hours	0	+	Injection partially into anterior wall. One small fresh adhesion of bowel loop to site of injection
15	M	1.5	1.0% in dist. water	4.5	7 days	+	+	Normal except mild genital inflammation
16	M	1.0	1.0% in dist. water	3.0	14 days	0	0	Normal
17	F	4.0	1.0% in dist. water	12.0	21 days	0	0	Normal
18	F	5.0	1.0% in dist. water	15.0	21 days	0	0	Normal
19	F	3.0	1.0% in dist. water	9.0	21 days	0	0	Normal
20	F	3.0	2% in dist. water	9.0	24 hours	-	-	Discarded. Injection into transverse colon
21	F	2.5	2% in dist. water	7.5	48 hours	+++	+++	Paried reaction. Pairing of intestines. Generalized adhesions - early
22	F	2.0	2% in dist. water	6.0	72 hours	++	++	Fresh membranous adhesions - mesentery and omentum
23	F	2.5	2% in dist. water	7.5	7 days	0	+	Recent adhesion of omentum to mesentery of small bowel and colon
24	M	1.5	2% in dist. water	4.5	14 days	0	0	Normal
25	F	3.0	2% in dist. water	10.5	18 days	0	0	Normal
26	F	5.0	2% in dist. water	15.0	19 days	-	-	All of injection into anterior wall. Nonabsorbing mass in wall
27	F	3.0	2% in dist. water	9.0	21 days	0	0	Normal
28	F	4.0	2% in .9% NaCl	12.0	24 hours	+++	+++	Generalized inflammatory reaction
29	F	2.0	2% in .9% NaCl	6.0	48 hours	+++	+++	Walling of intestines
30	F	2.0	2% in .9% NaCl	6.0	4 days	+++	+++	Inflammation, hemorrhagic. Intestine matted
31	M	2.0	2% in .9% NaCl	6.0	7 days	0	0	Normal
32	F	2.5	2% in .9% NaCl	7.5	21 days	0	+	Omentum slightly adherent to anterior wall
33	M	3.5	2% in amfelin	10.5	24 hours	++	++	Omentum adherent to large bowel
34	F	3.5	2% in amfelin	10.5	48 hours	+++	+++	Intestines loosely matted, by adhesions, early
35	M	3.5	2% in amfelin	10.5	4 days	+	+	Moderate adhesions between intestinal loops
36	M	2.5	2% in amfelin	8.0	7 days	0	+	Omentum adherent to anterior wall
37	F	2.5	2% in amfelin	7.5	21 days	0	++	Adhesions of omentum; dense, to lateral and anterior wall
38	M	3.0	3% in dist. water	9.0	24 hours	+++	+++	Inflammation, hemorrhagic. Adhesions of omentum to small intestine
39	F	3.0	3% in dist. water	9.0	48 hours	++	++	Intestines matted
40	M	4.0	3% in dist. water	12.0	72 hours	++	++	Localized abscess, well walled off
41	M	2.5	3% in dist. water	7.5	7 days	0	-	One adhesion. Omentum to anterior wall
42	M	2.5	3% in dist. water	7.5	14 days	0	0	Normal
43	M	2.5	3% in dist. water	7.5	21 days	0	0	Normal
44	F	3.0	3% in dist. water	9.0	21 days	0	0	Normal
45	F	4.0	3% in dist. water	12.0	21 days	0	0	Adhesion - omentum to small intestine and anterior wall
46	F	5.0	3% in dist. water	15.0	76 hours	-	-	Generalized severe inflammation and adhesions due to faulty injection into bowel wall
47	F	1.5	3% in dist. water	4.5	21 days	0	0	One fine adhesion - omentum to small bowel
48	F	5.0	3% in dist. water	15.0	21 days	0	0	Normal

+ mild; ++ moderate; +++ moderately severe; ++++ severe.

The general results of these experiments are condensed into the accompanying table. (Table II.) The degree of inflammation and the density of adhesions correspond to the condition found at necropsy.

**Inflammatory Reaction to Sodium Ricinoleate.** The degree of inflammation and the length of time that inflammation persisted was directly proportional to the concentration of sodium ricinoleate in distilled water. No evidence of inflammation was apparent after forty-eight hours when 0.25 per cent solution was employed; but it was apparent at the seventy-two hour examination when 2.0 per cent and 3.0 per cent solutions had been used. There was definitely more inflammatory reaction in the series injected with 2.0 per cent in normal

injected with 2.0 per cent in distilled water. In none of the animals was the solution fatal, except in the cases in which injection was made into the wall of the bowel. These faulty injections occurred in early experiments. To determine if necrosis of the bowel wall occurred when sodium ricinoleate solution was introduced into the peritoneal cavity with the certainty that the solution was introduced into the peritoneal cavity and with the certainty that the solution was *not* injected into the bowel, a series of cases was studied in which the solutions were introduced through an incision made under aseptic technic. No deaths occurred in this group and at necropsy the bowel was found to be intact. This series is not included in the

results recorded in Table 1, because of inflammation of adhesions which might result from operative trauma.

*Production of Adhesions by Sodium Ricin-*



FIG. 1. Appearance of the normal cecum of the adult rabbit.



FIG. 2. Appearance of the cecum of the adult rabbit soon after trauma.

*oleate*. In all cases after the injection of sodium ricinoleate definite fibrinous exudate was found early, but the persistency of this exudate in the form of organized adhesions after the seventh day was very infrequent. Adhesions were not found in any of the animals later than seven days after being injected with concentrations of sodium ricinoleate of 2.0 per cent or less in distilled water. Very small strands were found in two cases in which the 3.0 per cent and 4.0 per cent concentrations were used. In only one case were adhesions encountered in which 2.0 per cent solution in normal saline was employed. Adhesions were found in the animal killed after seven days and in the one killed after twenty-one days following the injection of 2.0 per cent sodium ricinoleate in concentrated amniotic fluid.

The foregoing experiments indicate that sodium ricinoleate in concentrations from 0.25 to 4.0 per cent in distilled water, 2.0 per cent in normal saline and 2.0 per cent in concentrated amniotic fluid produces a definite inflammatory reaction in the peritoneal cavity which is nonfatal. In all experiments a fibrinous exudate was formed following injection which infrequently resulted in the formation of organized adhesions. While the series is small in which sodium ricinoleate in concentrated amniotic

fluid was injected, adhesions were found more often in this series than in those in which distilled water or normal saline was used as a diluent.

#### STUDIES ON THE PERSISTENCE OF ADHESIONS AFTER TRAUMA TO THE CECUM OF THE RABBIT

Fifty adult rabbits were divided into five groups. Under sterile precautions and nembutal anesthesia, the abdomen was opened by an incision in the midline above the umbilicus. The entire cecum was traumatized by roughly pulling each segment through the fingers holding dry gauze. The abdomen was closed in two layers, chromic catgut being used in the peritoneum and muscles and linen in the skin, and a collodion dressing was applied. An additional dressing of three-inch stockinette was applied to the entire trunk, holes being cut for the legs. Ten control animals were untreated. Before closing the abdomen in the remaining animals, four groups of ten animals each received 20 cc. intraperitoneally, respectively, of 6.0 per cent gum acacia solution, 12.0 per cent gum acacia solution, concentrated amniotic fluid (Amfetin-Lilly) and 1.0 per cent sodium ricinoleate (Soricin-Merrell). The animals were killed and examined in each group after seven days. Cultures of the peritoneum were taken at the time of operation and at the time of examination. These were incubated on blood-agar media. All cultures were negative except that in

one animal the culture was positive at operation but negative at examination.

This method of producing adhesions was



FIG. 3. Adhesions of the omentum and cecum to the line of incision and adjoining parietal wall seven days after trauma. (Control animal.)



FIG. 4. Adhesions of the cecum to the line of incision and adjoining parietal wall and adhesion between large bowel and cecum seven days after trauma. (Control animal.)

considered to be very drastic. After traumatizing the cecum there were generalized petechial hemorrhages and numerous subserous hemorrhages. (Figs. 1 and 2.) Adhesions resulting in control animals were dense and difficult to separate. (Figs. 2 and 3.) Adhesions were more apt to occur between the cecum and the parietal wall, due to the position of the animals and to the compression of the abdomen by the stockinette dressing.

Upon examination it was found that all adhesions existed in one or more of four sites; omentum to cecum or parietal wall, cecum to parietal wall, cecum to folds of cecum or cecum to other structures such as mesentery, loop of small bowel or the tip of the uterus or ovary. The results are condensed in Table III:

TABLE III

No of Animals	Solution Used	Interval	Adhesions, Per Cent			
			Cecum- omen- tum	Cecum- parietal wall	Cecum- caecum	Cecum Else- where
10	Control	1 week	80	60	30	50
10	Amfctin	1 week	60	60	60	40
10	Acacia 6 per cent	1 week	40	60	10	10
10	Acacia 12 per cent	1 week	70	50	20	10
10	Sorcin 1 per cent	1 week	30	20		

Gum acacia solution was used because it was hoped that some lubricating effect might be obtained if the solution remained

within the peritoneal cavity. It has been found that gum acacia given intravenously persists within the circulatory system for many months. It was hoped that if acacia solution would remain on the circulatory side of the peritoneal cavity it would as well remain *without* the circulatory system if placed intraperitoneally. However, chemical tests of the peritoneal fluid after twenty-four hours failed to demonstrate the presence of acacia. Tests of blood serum were negative at the same interval. I am unable to say how this material was eliminated. However, since Auspitz<sup>38</sup> has demonstrated ground rice grains in the lung and spleen after intraperitoneal injection, it is not strange that acacia was removed.

The number of adhesions found after the use of amniotic fluid concentrate was almost as great as in the control group. Although this solution has been found to be stimulating to the peritoneum, it will be noted in the experiments of Seeley, Higgins and Mann<sup>23</sup> that this stimulation did not result in an appreciable increase of peritoneal fluid. Warren<sup>29</sup> states that amniotic fluid acts probably by reducing the oozing from injured surfaces. In the use of sodium ricinoleate there is a definite increase of peritoneal fluid. When we consider the scarcity of peritoneal adhesions in

tuberculous peritonitis with effusion it may be considered that exudation is of value in preventing adhesions. Further, in case of infection within the peritoneal cavity, absorption into the circulation is to be avoided. Sodium ricinoleate would not only tend to prevent absorption away from the peritoneal space, but to reverse this process by causing exudation of fluid and cells which are mixed with sodium ricinoleate known to be bactericidal, bacteriostatic and detoxifying.

The effects of sodium ricinoleate intraperitoneally may be summarized as follows: It causes an outpouring of exudate into the peritoneal cavity which is rich in neutrophils and monocytes, and from which is deposited dense fibrin. This furnishes fluid for lubrication, fibrin for healing, neutrophils for phagocytosis and lysis of fibrin and monocytes for regeneration of endothelium, thus imitating nature in the processes of primary healing. In case of infection, the presence of sodium ricinoleate further assists because of its bactericidal, bacteriostatic and detoxifying properties. Slowing or reversal of absorption from the peritoneal cavity is of additional value.

#### COMMENT

It should be emphasized that sodium ricinoleate solutions must be freshly prepared in pyrex glassware. I have found old stock solutions toxic, therefore, fresh stock should be used. Further, in an evaluation of adhesions in experimental work it is urged that very young animals and pregnant animals be avoided. I have noted that there is more peritoneal fluid in such animals, and adhesions are more difficult or impossible to produce even under control conditions. It is, therefore, obvious that an evaluation of substances designed to avoid unfavorable adhesions should be carried out in adult, nonpregnant animals. It should be further emphasized that any agent designed to prevent or reduce the number of adhesions must be introduced very early. Hertzler<sup>1</sup> states that coaptation

of surfaces takes place within ten minutes and that for this reason the postoperative posture, movement of the patient or stimulation of peristalsis is unsuccessful on this account.

#### CONCLUSIONS

Healing of the peritoneum is exactly parallel with the formation of adhesions. Any measure designed to prevent unfavorable adhesions must imitate nature's methods of healing, not inhibit such processes. The most certain method of avoiding unfavorable adhesions is the limitation *only* of trauma to the area in which healing is desired. When there is trauma elsewhere, or when foreign bodies, infection, digestive juices or factors which alter coagulation are present, healing occurs at unfavorable sites, and nature's processes should be stimulated. In the studies reported in this paper stimulation of the peritoneum by sodium ricinoleate has been shown to imitate nature's processes of healing by the production of an abundant exudate which is rich in neutrophilic polymorphonuclear leucocytes and monocytes, from which abundant fibrin is deposited. The presence of this abundant exudate acts as a lubricant to prevent the formation of unfavorable adhesions.

In addition, sodium ricinoleate possesses bactericidal, bacteriostatic and detoxifying properties and by slowing or reversing absorption from the peritoneal cavity assists in combating infection. Sodium ricinoleate has been demonstrated to be well tolerated intraperitoneally in laboratory animals and in the human. It has been demonstrated that it is capable of preventing the majority of unfavorable adhesions after drastic trauma to the viscera and peritoneum of animals.

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# ABDOMINAL ANEURYSM

## A REPORT OF TWENTY-FOUR CASES

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IT is the purpose of the authors to report this series of twenty-four cases of aneurysm occurring in the Philadelphia General Hospital in the last ten years, 1930 to 1940. During this period there were approximately 200,000 admissions to this institution, so that the condition is probably encountered here with more than average frequency. Our main endeavor will be to discuss what these cases offer us that may be particularly helpful toward making an early diagnosis.

Although abdominal aneurysm was first mentioned in the literature nearly 450 years ago, Kampmeier, writing in 1936, could find only 386 cases recorded in the literature and apparently little of diagnostic interest was presented during this period to justify much consideration being given the subject in our textbooks of today. Perusal of several of the most widely known texts reveals the fact that but a short paragraph is given to such discussion in any of them. This paucity of expression seems to us to justify any and every contribution that these twenty-four case reports may have to offer.

TABLE I  
AGE INCIDENCE

Age	No. of Cases	Percentage
30-40	6	25.
41-50	5	20.8
51-60	8	33.3
61-70	3	12.5
71-80	1	4.1
80-up	1	4.1

Lowest age—33  
Highest age—83  
Average age—51

As shown in Table 1, 79.1 per cent of the cases in this series of twenty-four occurred in patients between the ages of thirty and sixty, and about one-third (33.3 per cent) occurred between fifty-one and sixty years. There was a predominance in males, the ratio being approximately 5:1. In other earlier reported series this ratio has reached as high as 9:1 (Nixon). Distribution as regards race was about equal.

TABLE II  
SEX INCIDENCE

Sex	No. of Cases	Percentage
Male white 12 black 8.....	20	83.3
Female white 2 black 2.....	4	16.7

TABLE III  
WASSERMANN REACTION  
The Reaction Was Reported in Twenty-one Cases;  
No Report on Three Cases

Age	Positive	Negative	No Report
30-40	4	2	0
41-50	3	2	0
51-60	3	3	2
61-70	0	2	1
71-80	0	1	0
81-up	0	1	0
	10	11	3

We found that the Wassermann reaction was not reliable as to etiology of this condition since a negative Wassermann test was obtained in one case with definite findings at necropsy of a syphilitic aneurysm; and

in another case a positive Wassermann reaction was obtained in which evidence substantiated the diagnosis of an arteriosclerotic aneurysm. (Table III.)

Despite these two fallacies we note that only ten of the reported cases had syphilis and the other half had to have some other causative factor for the arteriosclerosis producing the aortic degeneration. In none of our cases was trauma given as an etiological factor.

TABLE IV	
Differential Diagnoses	No. of Cases
Abdominal aneurysm . . . . .	12
Hypernephroma . . . . .	5
Mesenteric thrombosis . . . . .	4
Coronary occlusion . . . . .	4
Retroperitoneal tumor . . . . .	2
Pancreatitis . . . . .	2
Gastric carcinoma . . . . .	2
Appendicitis . . . . .	2
Pott's disease with abscess . . . . .	2
Nephrolithiasis . . . . .	2

The differential diagnoses (Table IV) made during the course of the study of these cases were many, there being a total of fifty-two in the twenty-four cases. This table shows the number of diagnoses that occurred two or more times. In addition to these there were forty-two other single erroneous diagnoses. This high percentage of failure should be embarrassing to our hospital staff in this age of laboratory aids, particularly the roentgenogram, not mentioning the much older stethoscope. Actually, a correct diagnosis was made in just twelve of the patients, and in eight more a vascular lesion was the diagnosis. It will be noted also that in this series the total number of diagnoses was eighty-nine.

This list of diagnoses is given to illustrate how far afield one can wander in abdominal diagnosis, particularly when the symptoms and signs are in the left portion of the abdomen and especially the upper left quadrant. When we recall that fully 75 to 80 per cent of abdominal surgical lesions are midline or on the right, it simply means that we are not having our diagnostic acumen sharpened enough by the repetition of left-sided lesions.

TABLE V	
Symptom	No. of Cases
Symptoms in order of their frequency:	
Pain . . . . .	23
Constipation . . . . .	8
Dyspnea . . . . .	6
Vomiting . . . . .	6
Leg edema . . . . .	5
Weight loss . . . . .	3
Dizziness . . . . .	2
Mass in epigastrium	} . . . . . 1 each
Jumpy heart beat	
Weakness in leg	
Swelling in one leg	
Pain in leg	
Anorexia	
Nocturnal dyspnea	
Staggering	
Nocturia	
Hematemesis (massive)	
Melena	

The most common symptom was pain, present in twenty-three of the patients. The character of the pain varied from mild backache to the severe pain of a dissecting aneurysm which was unrelieved by large doses of morphia. It was described as a throbbing, pulsating pain in one case. The duration of the pain was also variable. One patient had pain only a few hours prior to admission while another had pain for four years. Here again the diagnostician is confronted with a difficulty in analyzing the pain. However, the fact that in only two of the cases was there any mention made of symptoms related to the digestive tract, vomiting in one and hemorrhage in the other, should narrow the field of mistakes. The complaint of constipation by eight of the patients represents but little increase of this condition in the average admission to any hospital. Pain radiating into the back, the groin, left testicle and down the left leg, is mentioned by several writers.

The origin of the pain was in the lumbar region in nine cases, abdominal in fourteen, and in the loin (left) in one case. There was radiation of the pain to the left groin, left testicle, and down the left leg in nine cases. Of these nine cases, 6 showed erosion of the vertebrae by roentgenogram, two showed no erosion and in the remaining one no roentgenogram of the vertebrae was taken.



The roentgenogram was employed in sixteen of the cases of which eleven showed erosion of the vertebrae and five, or 31 per cent, were reported negative. Several of the symptoms as dyspnea, leg edema, dizziness and nocturia were attributed to heart disease. One patient in the group had very little pain. The prominent symptom was massive hematemesis produced by rupture of an aneurysm of the celiac axis into the jejunum. Death occurred twenty-four hours after the onset of hemorrhage. When one reviews the above picture he finds such a varied, complex and bizarre collection of signs and symptoms which may have connection with pressure upon viscera and large vessels supplying such viscera as the kidneys, the liver, intestines, stomach, lower extremities, etc., that he must of necessity be reminded at least of not only the possibility but the probability of the existence of an aneurysm as the causative factor.

TABLE VI  
BASIS FOR DIAGNOSIS

	No. of Cases	Percentage
Presence of pulsating mass.....	13	54.1
Erosion of vertebrae by roentgenogram.....	3	12.5
Postmortem findings.....	4	16.7
History of previous laparotomy....	1	4.1
Laparotomy.....	1	4.1
Severe abdominal pain; absence of arterial pulsations in lower extremities.....	1	4.1
Sudden severe pain; shock.....	1	4.1

A positive statement as to the existence of a bruit or thrill was obtained in only five cases; in the remaining nineteen cases, no mention of a bruit was made. The most reliable finding upon which the diagnosis was based (Table VI) was the presence of a pulsating mass, demonstrated in thirteen cases (54.1 per cent). Of these thirteen cases the mass was definitely expansile in five cases. The relative infrequency of the findings of bruit and thrill may readily be

attributed to clotting in the sac rather than to careless physical examination. Aneurysms in the more superficial parts of the body are diagnosed earlier when bruit, thrill and expansile pulsation are easily recognized. There were two cases diagnosed by roentgenogram (erosion of vertebrae) and four diagnosed only at necropsy (abdominal aneurysm was not suspected in the last four cases). Farmer, in 1927, makes the statement that "a soft tissue mass may be seen by the roentgenologist but it must have calcified laminae in its substance to arouse strong suspicion of abdominal aneurysm." One case had a laparotomy thirteen months prior to admission and was diagnosed as abdominal aneurysm. One, diagnosed at laparotomy was suspected to have an intestinal obstruction. The case diagnosed because of severe pain and absent pulses in the lower extremities was one of a dissecting aneurysm of the aortic arch which dissected down the aorta and its branches occluding all the branches (including both renal and common iliac arteries). One case was diagnosed dissecting aneurysm because of sudden severe abdominal pain and shock in a patient with a mass in the left lumbar region. A roentgenogram in this case showed erosion of the vertebrae.

The blood pressure in these cases ranged from 60 to 250 systolic and 40 to 160 diastolic. Ten cases had systolic pressure under 120, and fourteen had pressure over 120.

In the twenty-four cases cited, the diagnosis in twenty was confirmed by postmortem examination or by exploratory laparotomy. Of the sixteen cases that had postmortem examination, ten showed a rupture of the aneurysm, nine being retroperitoneal and one into the jejunum. Of the eight without a postmortem study, two showed clinical evidence of rupture. The diagnosis in the remaining four was confirmed by the presence of a pulsating abdominal mass and evidence by roentgenogram of erosion of the vertebrae. Six patients left the hospital, three of whom had been operated upon.

#### TREATMENT

Exploratory laparotomy was done in seven cases. Reparative work directed toward the aneurysm was done in five cases, three of which were wired, ligation of the left common iliac artery for ten days in one case and an attempted arteriovenous anastomosis between the iliac vessels in one case.

#### SUMMARY

Twenty-four cases of abdominal aneurysm have been reported.

The etiology has been discussed with especial reference to the Wassermann test.

A study of the symptomatology and the

differential diagnosis has been made with emphasis laid upon the frequency of error.

A pulsating mass was found to be the most frequent diagnostic symptom, while bruit and thrill were noted in only five cases.

The diagnosis was confirmed in twenty of the cases by postmortem or laparotomy.

The authors wish to express their appreciation to the various members of the Staff of the Philadelphia General Hospital for permitting the use of their case records in this review.

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EVER since the classic report of van den Velden more than sixty years ago it has been repeatedly shown that achlorhydria and hypochlorhydria characterize the gastric secretory status of the majority of patients with gastric carcinoma.

From—"Carcinoma and Other Malignant Lesions of the Stomach"—by Waltman Walters, Howard K. Gray and James T. Priestley (W. B. Saunders Company).

# PEMPHIGUS VULGARIS OF THE URINARY BLADDER\*

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**P**EMPHIGUS vulgaris of the gastrointestinal tract is not uncommon, but pemphigus of the urinary bladder is very rare and is seldom diagnosed before postmortem examination.

The following case report is of interest in that the patient presented pemphigus vulgaris of the urinary bladder as well as the cutaneous surface and the gastrointestinal tract. The clinical diagnosis of pemphigus of the urinary bladder was confirmed by cystoscopy and definitely proved by histopathological examination of portions of the organs obtained at necropsy seven days after the cystoscopic examination.

## CASE REPORT

M. F., a white, married Jewish woman, forty-three years of age, was admitted to the Post-Graduate Hospital on August 19, 1940. Seven weeks previous to her admission she noticed a vesiculobullous eruption on her arms, which spread within a week to her neck, face, shoulders, forearms and wrists. Three weeks before we admitted her, the patient was in a hospital in New Brunswick, New Jersey, for seventeen days where she received a course of sulfanilimide during which the blood sulfanilimide level was maintained at 7 to 8 mg. per 100 cc. for several days, and vitamin D in daily doses of 100,000 units for one week. Despite these therapeutic measures, the eruption became more extensive.

On admission to Post-Graduate Hospital the patient presented a generalized cutaneous bullous eruption which was diagnosed clinically as pemphigus vulgaris with acute and subacute eczematous manifestations. The Nikolsky phenomena could be elicited in all supposedly normal skin areas. There was a painless, pea-sized flaccid bullous lesion on the right tonsil. The external genitalia were free of the eruption. A blood count revealed a moderate secondary

anemia, and a moderate polymorphonuclear leucocytosis. There was slight stippling and anisocytosis of the red blood cells, and a few slightly toxic leucocytes.

Urine analysis showed a dark amber, acid urine, with a specific gravity of 1.020. There were 2 to 4 red blood cells, 1 to 3 white blood cells per HPF, and a faint trace of protein. A few round cells, many squamous cells (some in clumps), many bacteria, and a few yeast cells were observed. The temperature was 101.2°F., pulse 130 and respirations 24 per minute.

On August 22, the patient noticed some difficulty in voiding but on the twenty-third, twenty-fourth and twenty-fifth she voided normally. Similar symptoms were again noted on the twenty-sixth, twenty-seventh and twenty-eighth when she was seen in consultation with the genitourinary surgeon. A sterile catheterized specimen of urine was obtained for analysis and culture. The urine was dark brown in color, very cloudy, and foul smelling, alkaline in reaction, with a specific gravity of 1.010. There was a trace of acetone, and 2 plus protein. Ten to 15 white blood cells per HPF with a few large clumps of pus cells were found; no blood cells were noted, but a 4 plus benzidine reaction for occult blood was present. On culture, the urine showed *Bacillus coli* and non-hemolytic streptococci, but *Staphylococcus aureus* was recovered from the blood on culture.

On August 26, the icteric index, urea N, serum chlorides, true glucose, and cholesterol were normal. The total proteins were 4.2 per cent with albumen 1.8 per cent and globulin 2.4 per cent and an albumen-globulin ratio of 0.75.

On August 28 and 29 the patient voided freely, but on the following day there was considerable difficulty which subsided on August 31. On September 1 and 2 she developed nocturnal urinary incontinence.

On September 3 a cystourethroscopic examination revealed the following: With local

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anesthesia of the urethral mucosa only, a No. 24 F panendoscope was introduced into the bladder without difficulty. Foul-smelling, thick brownish urine was obtained. The bladder capacity was good and the patient evinced practically no pain or discomfort throughout the examination, even on overdistention of the bladder. A considerable amount of flaky white and grey debris was noted in the medium. In the posterior upper portion of the viscus, the normal mucosa appeared injected. On the posterior base and lateral walls it was hemorrhagic. The left anterior and lateral portions were markedly inflamed with dark, reddish-brown erosions and ulcerations interspaced with areas of bullous edema. Adherent membranous mucopurulent material was widely distributed over the inflamed portions of the bladder. The right ureteral orifice appeared normal. The left could not be observed owing to the inflamed, thickened mucosa and membranous material covering the left bladder floor. The internal vesical sphincter was normal in contour and appearance and was not elevated. The floor of the proximal portion of the urethra showed a dark, reddish-brown discoloration. A mushroom catheter was inserted and tidal irrigation instituted.

A diagnostic film on this date showed no abnormality of the urinary tract, but the lumbar spine showed a marked rotation and right lateral curvature. On September, 3 and 5 the urea nitrogen, uric acid, creatinine and carbon dioxide combining power were within normal limits. The serum chlorides, true glucose and total calcium were normal on September 6.

Despite the use of germanin, sodium sulfapyridine, sulfapyridine, blood transfusions, daily infusions of glucose in saline and other methods of supportive therapy, the patient expired on September 10. Throughout the course in the hospital the patient's temperature was septic, fluctuating between 98° and 104.4°F. daily. There was always a concomitant elevation of the pulse rate. The temperature rose to 106.4°F. on September 9, but returned to 103°F. before death.

**Necropsy Report.** The skin was dry and scaly in texture and almost completely covered by numerous small crusted lesions, up to 2 cm. in diameter. The lesions were most prominent on the face, ears, chest, buttocks and extremities. A large decubitus ulcer, 6 cm. in diameter was noted over the sacral promontory. On histological study the rete pegs were slightly

shortened and thickened, and the basal layer of the epidermis vesiculated and slightly edematous. The papillae were narrowed and flattened,



FIG. 1. Kidney, ureter and bladder—showing evidence of pemphigus vulgaris in the bladder.

the intercellular bridges of the prickly cells of the epidermis unusually prominent. Many of the papillae were edematous, and the blood vessels in the upper portion of the dermis were surrounded by a moderate number of lymphocytes, polymorphonuclear leucocytes and plasma cells.

A few small atheromatous plaques were seen on the intimal surface of the ascending portion of the aorta. The apices of the upper lobes of the lungs were grey, contracted and fibrosed with the visceral pleura over these areas firmly attached by fibrous adhesions, to the adjacent parietal pleura. The right, middle and lower lobes were crepitant throughout. The lungs revealed chronic passive congestion of the lower lobes and bilateral, healed apical lesions.

The spleen and adrenals were normal, and the liver showed evidence of chronic passive congestion. The cut surface of the cortex and

medulla of the kidneys was congested, and the demarcation between them indistinct. (Fig. 1.)

The genital tract was essentially negative. The urinary bladder was normal in size. The serosal surface was smooth, pink and glistening; and on section, the wall was uniformly 3 to 4 mm. thick. The bladder contained about 30 cc. of foul-smelling, cloudy, yellow urine. The mucosal surface was markedly engorged and studied with numerous discrete, irregularly round, yellow, partially necrotic plaques, up to 15 mm. in diameter. These lesions were not found over the surface of the markedly engorged trigone, nor did they involve the mouths or distal portions of the ureters. The urethra was patent and had a red, congested epithelial lining.

The wall of the esophagus was uniformly 3 mm. thick, the mucosa was moderately hemorrhagic. The stratified squamous epithelium was missing for the most part, and where it remained, was poorly preserved. The mucosa was covered with a thin layer of fibrin, desquamated epithelial cells, red blood cells, lymphocytes and debris, and was engorged and sprinkled with polymorphonuclear leucocytes and lymphocytes; the muscularis mucosa was fragmented and many of the muscle fibers were hyalinized. The submucosa, muscle and subserosal layers were edematous and had numerous congested blood vessels. The stomach contained about 100 cc. of brown, turbid fluid. The mucosa was grey and bile-stained. The duodenum was unaltered; the small intestine contained about 100 cc. of yellow chyme. On the mucosa, on the posterior wall of the cecum, there was an elevated, irregularly round, partially necrotic plaque, 2 cm. in diameter, similar to those described in the urinary bladder. The mucosa of the cecum was poorly preserved and the epithelial layer had disappeared. The villi were markedly engorged and infiltrated with polymorphonuclear leucocytes and lymphocytes. A few of the smaller blood vessels were filled with organizing thrombi. The submucosa was markedly edematous and sprinkled with polymorphonuclear leucocytes and lymphocytes. The muscle and subserosal layers were edematous.

#### DISCUSSION

A review of the American Literature from 1890 to 1940 reveals no observations pertaining to pemphigus vulgaris of the

urinary bladder. The first recorded case of chronic pemphigus vulgaris in which the urinary bladder was primarily involved is that of von Ludwig in 1897. In 1904, Schild cited a similar instance of pemphigus vulgaris with involvement of the urinary bladder. Fabry, in 1904, reported a case of pemphigus foliaceus in which he suspected involvement of the urinary bladder because of the presence of blood in the urine. Bernhard, in 1902, described bladder involvement in a case of pemphigus vegetans. Von Purgesz, von Rayer, and Scholus, each reported bladder involvement in cases of chronic pemphigus vulgaris, making a total of seven cases. We do not believe that this condition is as rare as these figures would imply and are of the opinion that prompt cystoscopic investigation of symptoms referable to the urinary bladder will reveal many cases that would be otherwise unrecognized.

The presence of urinary disturbance with hematuria and pyuria in the course of pemphigus vulgaris should direct attention to possible involvement of the bladder. The cystoscopic determination of its presence under these circumstances presents no great difficulty. However, where it is primary to the bladder or urethra, as in von Ludwig's case, the findings may be misinterpreted unless the cystoscopist is on the alert,

In the earlier and intermediate stages, before infection has changed the picture, the characteristic bullae are helpful. When inflammation has advanced to the stage where the earlier lesions are obscured and supplanted by bullous edema, erosions, ulcerations with adherent membranous debris, an appearance is presented which no longer is typical of pemphigus vulgaris, but suggests a profound inflammation of the viscus with probable invasion of the bladder wall such as is seen in tuberculosis and other serious invasions of the bladder.

The absence of reduced bladder capacity, pain and discomfort on cystoscopic examination in the presence of profound inflammatory change noted in this patient appears

worthy of comment. The limited literature on this subject fails to reveal any mention of the syndrome, which, if substantiated by similar findings in other cases of pemphigus vulgaris, will prove valuable both in the diagnosis and differentiation of the vesical form of this disease.

#### CONCLUSIONS

1. The recorded cases of pemphigus vulgaris of the urinary bladder are extremely rare. The condition is seldom diagnosed before necropsy.

2. Prompt investigation of bladder manifestations will reveal many cases of vesical involvement.

3. A review of both the American and foreign literature from 1890 to 1940 reveals no observation in the former and only seven recorded cases in the latter.

4. This, the eighth published case, is of

interest in that the clinical diagnosis was made by urethrocystoscopy and confirmed by postmortem examination.

5. The profound inflammatory change in the bladder mucosa with excellent tolerance on instrumentation noted in this case is worthy of comment.

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# THE DIAGNOSIS OF TORSION OF THE PEDICLE OF AN OVARIAN CYST\*

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**T**ORSION of the pedicle of an ovarian cyst is an acute abdominal emergency, the diagnosis of which can be made in a great majority of cases. Although the condition is not seen with great frequency, it occurs with sufficient regularity to demand that its possibility be constantly kept in mind by the operating surgeon. Twisted ovarian cyst has been a known clinical entity for at least seventy-five years, but there have been few publications on the subject during the last decade.

Torsion of the pedicle of an ovarian cyst may occur at any age but it is seen during the second, third, and fourth decades most commonly. Reuben<sup>20</sup> collected ninety-nine cases in children, and Haines and Edgerly<sup>8</sup> found thirteen cases in girls under seven years of age. These authors emphasize the necessity of considering this condition in surgical emergencies in children. Robins<sup>18</sup> has reported a case in a woman seventy-seven years old, and this report includes a patient of eighty-seven years and one of seventy; hence the condition should even be considered by the specialist in geriatrics when an acute abdominal emergency appears in the aged.

It is difficult to estimate how frequently the pedicle of an ovarian cyst undergoes torsion. Grotenfeldt<sup>7</sup> has tabulated the experience of a group of thirty-six surgeons concerning the frequency that torsion is found in operations for ovarian cyst. The frequency varied from 2 to 47 per cent. It is certainly apparent that it is difficult to estimate its frequency, and the review of a single institution's or surgeon's experience with ovarian cysts gives an erroneous conception of the frequency, as many simple

cysts cause such slight symptoms that medical care is never sought, while when torsion occurs, the severe symptoms almost invariably necessitate hospitalization.

TORSION OF OVARIAN CYSTS  
Incidence by Age Groups

Age Group Years	No. of Patients
10-15	2 (11) (14)
15-20	6
20-25	9
25-30	9
30-35	9
35-40	11
40-45	7
45-50	4
50-55	8
55-60	1
Over 50	3 (65) (70) (87)

The records of sixty-nine patients with torsion of the pedicle of an ovarian cyst who were operated upon at Cook County Hospital during the sixteen-year period 1925 to 1940 are reviewed in this paper.

*Etiology.* The exact cause of torsion of the pedicle can be ascertained but rarely. The early publications contained much speculation on the subject. Payr<sup>15</sup> thought that increased venous congestion tended to cause torsion while Jolly<sup>10</sup> believed that the expansile force of the growing tumor in some cases tended to increase the frequency of torsion. Certain predisposing factors are known, with reasonable certainty, to exist in the production of torsion. Smooth, free cysts of small to moderate size on a long, thin pedicle undergo torsion most commonly. Frank,<sup>4</sup> Bernstein<sup>3</sup> and others have found that solid tumors undergo torsion more frequently than cystic tumors.

Changes in intra-abdominal pressure seem to initiate torsion in some cases; this may account for cases seen during preg-

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nancy or the puerperium. In this series seven patients (10 per cent of the series) were operated upon during pregnancy or during the first six months of the puerperium. In addition, several cases not included in this report were seen with symptoms suggesting ovarian torsion associated with pregnancy. These patients were not operated upon as their symptoms tended to subside.

Occasionally, trauma is associated with the initial symptoms of ovarian torsion. In three patients (4.2 per cent) in this series the onset was dated from an injury or some unusual strain. In one the patient first complained after striking her abdomen on a wash tub; one dated her symptoms from a sudden turn in bed while the final patient first experienced pain after an unusual reach. The traumatic and medicolegal aspects of ovarian torsion are discussed in the excellent paper by Sneierson, Schlesinger and Gold.<sup>22</sup>

*Pathology.* There may be any number of turns of the pedicle of an ovarian cyst from one-half turn to twenty-five. In some cases a rotation of 180° may be sufficient to affect the blood supply; while in others numerous turns do not impair the circulation at all. Rotation usually occurs in a clockwise direction on the right side and in a counter-clockwise direction on the left. This is known as Küstner's law<sup>12</sup> and is said to be true in 85 per cent of cases (Pfannensteil).<sup>16</sup> Retorsion or spontaneous restitution occasionally occurs; Grotenfeldt<sup>7</sup> collected seven cases in the literature and added six more cases seen by himself.

The type and extent of the pathological changes depend on the degree of vascular impairment produced by the torsion. A moderate twist may be sufficient to obstruct the venous return but not affect the arterial supply. This causes congestion and in some cases produces hemorrhage into the cyst. Because of the anastomosis between the ovarian and uterine veins in the broad ligament, there is also congestion and edema of the uterus, tube, and broad ligament although to a less extent. Progressive

hemorrhage into the cyst may continue to such an extent that rupture occurs. In this case symptoms closely simulating rupture of an ectopic pregnancy may ensue. Occasionally, the hemorrhagic cyst may become infected from the nearby bowel. When torsion is sufficiently marked to obstruct the arterial supply, necrosis, gangrene and subsequent infection usually occur. In some cases calcification is the end result. The advent of marked torsion produces the particularly severe symptom complex.

Torsion of practically every type of ovarian tumor has been reported in the literature. One case reported in this series on pathological examination appeared to be strangulated normal ovarian tissue. This is a rather rare condition which has been discussed by Barron.<sup>2</sup> In this series 69 per cent were grouped in the category of simple ovarian cysts (Gardiner's classification).<sup>5</sup> This includes follicular cysts, corpus luteum and hemorrhagic cysts. The pathological findings of the cysts in this series are tabulated below:

TWISTED CYSTS FOUND IN THIS SERIES  
(Gardiner's Classification)<sup>5</sup>

Group I—Simple Retention Cysts	
A—Follicular cysts.....	30
B—Hemorrhagic cysts.....	6
Group II—Endometrial Cysts.....	2 (chocolate cyst)
Group III—Neoplastic Growths	
A—Epithelial growths	
1. Pseudomucinous cystadenoma.....	2
2. Papillary cystadenoma.....	3
3. Carcinoma.....	1
B—Embryoma	
1. Dermoids.....	7
C—Connective tissue tumors	
Group IV—Inflammatory Cysts...	2
Parovarian cyst.....	1
Interligamentous cyst.....	3
No report.....	11

*Clinical Manifestations.* Abdominal pain, the most common complaint, was present in sixty-eight patients (98.5 per cent). It was the presenting symptom in sixty-six cases (95.6 per cent). In most cases the pain was described as sharp or cramping and was considered severe in sixty-four patients (92.7 per cent). The pain was usually located in the lower abdomen and in most cases localized to the



affected side. The pain radiated to the back in sixteen cases (23.1 per cent) and to the anterior and lateral aspect of the thigh on the involved side in eleven cases (15.9 per cent). Radiation down the thigh is significant when present and is accurate in determining the side of the lesion; the diagnostic value of this finding has been emphasized by Koucky.<sup>11</sup> In this connection one case in this series is of particular interest. This is a case of bilateral torsion of ovarian cysts, an uncommon occurrence which has previously been described in case reports by Armstrong<sup>1</sup> and Prichard.<sup>12</sup> On one side torsion had advanced to the point of strangulation of the cyst; on the other side, although torsion was present, there was no evidence that the blood supply was impaired. This patient had characteristic radiation of pain down the anterior and lateral aspect of the thigh on the side of the strangulated cyst. This radiation probably occurs through the second lumbar nerve which supplies the pelvic organs and the anterior and lateral aspect of the thigh.

Nausea and vomiting were usually present and occurred following the abdominal pain. The vomiting was not complete or unusually protracted in any case. This finding was present in forty-eight cases (69.5 per cent).

No characteristic menstrual disturbance was found in this series. Of sixty-seven patients with adequate menstrual histories fifty-seven (85 per cent) associated no change in their menses with their symptoms. Thirty-five (52.2 per cent) gave a history of regular periods; twelve (17.9 per cent) were past the menopause; four (5.6 per cent) were pregnant; one had been pregnant but had had an induced abortion a short time before, and one was in the prepuberal stage. Of ten patients (15 per cent) who had noticed menstrual irregularities beginning at the same time or before the symptoms of torsion, three had amenorrhea; three had metrorrhagia; two noticed delay in onset of periods; one had scant flow, and one had early onset of periods.

Abdominal tenderness was present in a

large majority of the cases and was usually localized over the site of the lesion, although in some cases it was generalized. It was present in sixty-three patients (91.3 per cent). Abdominal rigidity was found in nineteen patients (27.2 per cent). This finding indicated in most cases that the blood supply of the ovary was severely compromised or that rupture or hemorrhage had occurred.

A palpable mass was present on either abdominal or pelvic examination in fifty-eight patients (84 per cent). In three cases in which no mass was found, pelvic examination was not done; while in three other patients, abdominal rigidity was sufficiently marked to make palpation of a mass impossible.

Most of the patients had a low grade fever and a moderate acceleration of the pulse rate. Occasionally, the fever was found to be as high as 102°F. (38.8°C.) or more, but usually it was between 99°F. (37.2°C.) and 100°F. (38.8°C.). Fifty-five patients (79.8 per cent) had a fever of 99°F. or over (37.2°C.) on admission while forty-seven (68.1 per cent) had a pulse rate of 90 beats per minute or more. The leucocyte count was over 10,000 per cubic mm. in 76 per cent of the patients in which this procedure was done.

Fifty-nine (85.5 per cent) of these patients had borne children while ten (14.5 per cent) were nulliparous. Torsion occurred on the right in 60.8 per cent and on the left in 39.2 per cent. All of these patients had the twisted cyst removed at operation; several had salpingectomy at the same time, while in a few a hysterectomy was also done. In one patient a cesarean section was done in addition to oophorectomy. Most of the patients were hospitalized for twenty-one days or less; fifty-six (81 per cent) were discharged in twenty-one days or less while forty (58 per cent) were discharged in fifteen days or less.

*Diagnosis.* The palpation of a mass connected with the uterine adnexia is vital in establishing a diagnosis of twisted ovarian cyst. In this series a mass was

palpated in 84 per cent of the patients. Of eleven patients in which no mass was found, three did not have pelvic examinations, and in three rigidity of the abdominal muscles prevented a satisfactory bimanual examination. From these figures it is reasonable to conclude that a mass will be found in practically every instance if a careful examination is done. Examination under anesthesia should be used in every case in which the ordinary pelvic examination is unsatisfactory.

The following is a simulated history of a typical patient with torsion of the pedicle of an ovarian cyst:

A thirty-year old multipara who has been feeling perfectly well previously is suddenly seized with a sharp, severe cramping pain in the lower portion of the abdomen. This pain is present in her entire lower abdomen but is more severe on the right side. The pain is so severe that she is forced to stop her housework and go to bed. Shortly after going to bed she suddenly feels nauseated and vomits. The pain persists while she is in bed and even seems gradually to become somewhat more intense. She recalls having had a similar but milder attack two months previously which gradually passed off. About four hours after the onset she eats a light lunch but becomes nauseated about one-half hour after eating and vomits. The pain still remains in the same location and its character has not altered. She has no other complaints. Her bowel movements have been normal and her periods regular. She experiences no difficulty voiding; in fact there seems to be a brief but noticeable decrease in her pain following urination.

As the pain seems to have become somewhat more severe, the patient summons her physician; approximately twelve hours have elapsed since the onset. He finds the patient to be a well developed and nourished female whose temperature is 99.6°F. (37.6°C.); her pulse rate is 96 beats per minute, and her respirations are 20 per minute. The head, neck, chest and extremities show no abnormality. Her abdomen is soft and relaxed. On examination with a stethoscope the peristaltic sounds are found to be of normal frequency and intensity. There is tenderness over the entire lower portion of the abdomen, but it is most marked low in the right lower quadrant. A mass can be palpated

in this region; it is about the size of a small orange but is so tender that little else about its character can be determined. The mass can also be felt by pelvic examination but here, too, the tenderness precludes a more exact examination. He believes that exploration of the abdomen is indicated and advises hospitalization. By the time she reaches the hospital, the pain has become even more intense; in fact since the onset the pain has become progressively more severe. Her leucocyte count is 12,500 per cubic mm. There are 85 per cent polymorphonuclear forms. A flat plate of the abdomen shows no evidence of calculi or intestinal obstruction. She is examined under anesthesia just prior to operation and at this time a mass the size of a baseball is found in the right pelvis. The mass is smooth, freely movable and feels cystic; it seems to be connected with the right adnexia. The diagnosis of torsion of the pedicle of an ovarian cyst seems reasonably enough assured to make a midline incision.

It is readily seen that the directing and differentiating finding in this record is the palpable mass. This should be carefully sought for in every abdominal emergency. When the examination is at all unsatisfactory because of rigidity or tenderness, examination under anesthesia should be done. Fortunately the opportunity for this is present when the patient is being anesthetized for surgery, and this opportunity should be regularly utilized. This procedure in many cases will establish the diagnosis; while in practically all instances, it will aid the surgeon in choosing the incision which offers the greatest facility for the performance of the operation.

There are several factors which aid in the diagnosis of torsion of the pedicle of an ovarian cyst although these findings will not be present in a majority of cases. The patient may have been aware of the presence of a mass in the abdomen for some time. If she notices an increase in the size of the mass following the onset of her abdominal symptoms, this is highly suggestive of hemorrhage into the cyst following torsion. The radiation of pain down the anterior and lateral aspect of the thigh although present in only 15.9 per cent of

the cases in this series is sufficient characteristic to justify consideration of torsion of the pedicle of an ovarian cyst whenever this finding is present.

In some cases considerable valuable information can be obtained from a flat plate of the abdomen. Ordinarily, by the time a simple ovarian cyst has reached sufficient size to produce a shadow by x-ray, it can be easily palpated by physical examination, although it may be difficult even in cysts of moderate size to be sure that the shadow in the x-ray is an ovarian cyst. Dermoid cysts on the other hand can be diagnosed with reasonable certainty whenever teeth or bone are present. Glass and Rosenthal<sup>6</sup> found that calcareous deposits were present in 49.4 per cent of the dermoid cysts of the ovary reviewed by them while Marshall<sup>13</sup> found that only 18 per cent of his series of dermoid cysts had bone or calcareous material. Robins and White<sup>19</sup> find that a diagnosis of dermoid cyst can be made in some cases even in the absence of calcareous material. They find that dermoids by x-ray are characterized by a round or oval mass of decreased density, regular in contour, which has a banded mottled appearance. The mass is delineated by a thin ring of increased density. In children the diagnosis of torsion of an ovarian cyst is notoriously difficult. However, many of the cysts in the low age groups are dermoids, and the x-ray will be of great aid in making the diagnosis. The x-ray is also of value in helping to rule out some of the abdominal conditions which might easily be confused with a twisted ovarian cyst.

#### SUMMARY

The records of sixty-nine patients with torsion of the pedicle of an ovarian cyst have been reviewed. Certain aids in establishing the diagnosis have been discussed.

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# DISLOCATION OF THE TOES

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**D**ISLOCATION of one or more toes in the metatarsophalangeal joints is a rare occurrence, just like the luxation of the fingers in the corresponding metacarpophalangeal joints. But while the displacement of the big toe, due to its exposed position, is more frequent than an injury of the four lateral toes, it is still less common than the analogous one of the thumb.

## FREQUENCY AND OCCURRENCE

According to the statistics of René Sommer,<sup>5</sup> collected from large series of all types of luxations, dislocations of the toes were found in fifty-one cases or 0.8 per cent, the greater part of it affecting the big toe.

It is interesting to note that before the increase of industrial accidents, an overwhelming majority occurred to people connected with horses, such as riders and drivers. Malgaigne, for instance, found fourteen cases out of seventeen among horsemen. Slipping off the stirrup-plate while mounting a horse has been described in two cases. Another was caused by stepping upon the calk of a horseshoe lying on the ground. Notta saw a dislocation of the big toe when the foot was run over by the wheel of a car. A dislocation to the medial side, caused in the same manner was observed and reduced by Mouchet.<sup>3</sup>

A fall from a horse or with the horse is several times mentioned in the literature. Letenneur took care of an officer who had a dorsal dislocation of the big toe accompanied by a subluxation of the first metatarsal upon the first cuneiform. The only lateral dislocation of the first toe has been described by Ssolowjew (1907), brought on by a forced pronation of the foot while falling with the horse. The base of the phalanx was pushed in between the heads

of the first and second metatarsus. The skin over the medially protruding head of the first metatarsal was taut and porcelain-white, later becoming gangrenous.

Since the luxation of the big toe hardly ever gives rise to any doubt as to the diagnosis, we will restrict ourselves here chiefly to the injuries of the four lateral toes. It is obvious why dislocations of the smaller toes are so rare. The basal phalanges of the toes are rather short, thus providing merely a small lever for a traumatizing force. They are also well protected by the leather sole of the shoe which prevents the necessary hypermotility, and especially hyperextension. As shown, however, by accidental or late discovery of neglected cases, we may assume that some are not recognized at all.

Failure to make the correct diagnosis on the smaller toes in spite of an x-ray picture may be due to two facts:

First, a dorsoplantar view alone does not always show the metatarsophalangeal joints very well, because the contours of the bones are often more or less overlapping, particularly if the toes are in a cocked-up position as in the case of existing hammer-toes. A lateral or oblique view, on the other hand, might be difficult to interpret, because some of the joints are projected one over the other. However, if the possibility of a dislocation is kept in mind after a careful history and clinical examination, the inspection of the radiographs should positively eliminate any doubt.

Second, a delayed or overlooked diagnosis is due to injuries which dominate the picture, such as fractures of the limbs, the skull or the spine. If these injuries prohibit early walking, a dislocation of a toe might well pass unrecognized for it seldom causes any pain or discomfort. Moreover, unlike

luxations of fingers, the displacement is not very conspicuous of one or more toes in the basal joints, save the one of the big toe.

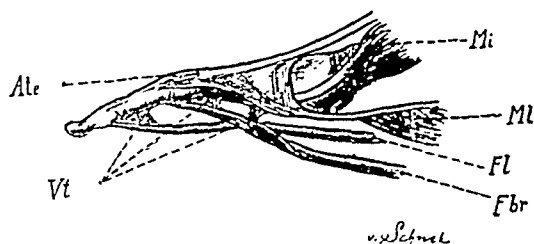


FIG. 1. View of second toe from medial side, showing relation of tendons to joint capsule and ligaments. Ate, aponeurosis of the extensor tendon; Mi, musculus interosseus dorsalis; Ml, musculus lumbricalis; Fl, tendon of flexor digiti longus (perforans); Fbr, tendon of flexor digiti brevis (perforatus); Vt, vincula tendinum.

Because of the variable lengths of the four lateral toes it is difficult to decide whether or not a shortening is present. The thick and dense cushions of the plantar structures tend to cover up any existing prominence of one or more metatarsals.

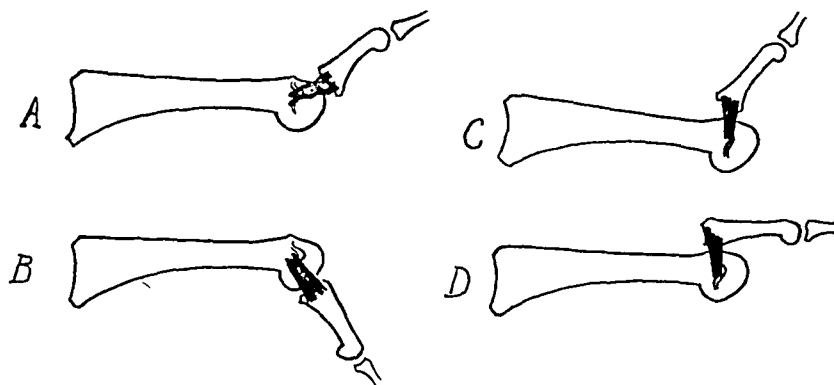


FIG. 2. Diagrammatic view of the collateral ligament under different conditions. A, ligament relaxed in slight dorsiflexion of toe; B, ligament taut in volar flexion of joint; C, ligament taut with toe in dorsal subluxation; D, ligament taut with toe completely dislocated.

A typical deformity indicative of a dislocation can be seen only within the first few hours following the accident. Examination later reveals a diffuse swelling of the foot over the dorsal aspect, including the area of the joints involved, as well as a circumscribed tenderness and limited motility. Forty-eight hours up to one week following the trauma, a subcutaneous, localized plantar hematoma might develop.

In the presence of these signs, the decision as to whether there is a fracture or a dislocation rests entirely upon the x-ray findings. Due to the same mechanism both may exist together. The absence of crepitation as a differential diagnostic aid is not very reliable.

Theoretically, the basal phalanx can be displaced in four directions: dorsal, plantar, medial or lateral. The dorsoproximal dislocation is the most common. Some cases, however, show a combination in this way that the toe is completely dislocated dorsally, partially to one side and at the same time being more or less rotated. An explanation for this may be seen in Riedinger's experiments. He found that the dorsal displacement is possible only after angulation and rotation.

Available case histories so far have not always been very clear in their description of the trauma. Most accidents are brought on by a fall or a forced jump on uneven ground, or a crushing injury to the foot,

which may have had little or no protective footwear.

A dislocation of the fourth and fifth toes was seen by Chauvin<sup>1</sup> after a fall five meters high on rough ground, exactly like the one described in our Case 1. Another one was seen by Ullrich<sup>6</sup> after a leap into shallow water. Mouchet<sup>2</sup> found a dislocation of the fourth toe caused by bumping the extended and somewhat adducted foot.

Only one case of luxation of all toes to the lateral side has been observed by Pailloux and Josse.

four principal ways in which the injury is acquired:

The most common cause apparently is

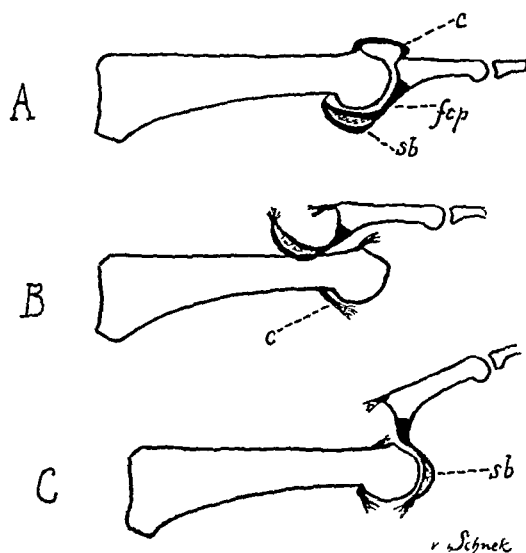


FIG. 3. Diagrammatic view of joint capsule under normal and pathological conditions. A, insertion of capsule closely to cartilage, forming a triangular lip plantar at the base of the phalanx; B, complete dorsal dislocation. The volar part of the capsule with the sesamoid bone is incarcerated. C, dorsal subluxation. Plantar part of capsule drawn hood-like over the head of the metatarsal. c, joint capsule; fcp, fibrocartilaginous plate; sb, sesamoid bone.

In some cases concerning horsemen the pressure from the stirrup seemed to be responsible. In 1915, Orth obtained a very good description from a cavalryman who fell with his horse and suffered a medial dislocation of the fifth toe. As weight-bearing was very painful, open reduction was performed with good results.

Styx reported about a chronic luxation of the second toe. Pressure against the prominent base under forced longitudinal traction would reduce it, but it reoccurred with the next active movement.

In one case, in which a man fell forward from a wagon while the tip of his boot was caught between two boards, luxation took place, forcing the toe in hyperflexion.

#### MECHANISM OF THE DISLOCATION

An analysis of these histories as to the mechanics and our own observations show

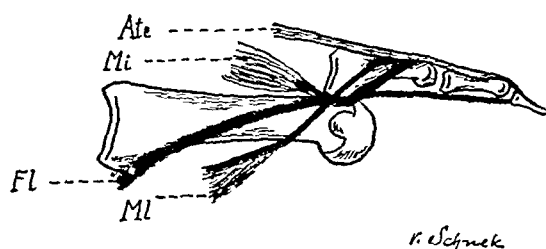


FIG. 4. Diagrammatical view of dorsal dislocation with incarceration of tendons. Ate, aponeurosis of extensor tendon; Mi, musculus interosseus; Ml, musculus lumbricalis. The tendons of these two muscles are blending with the dorsal aponeurosis. Fl, tendon of m. flexor digiti longus.

forced hyperextension. The plantar part of the joint capsule is torn from its insertion on the head of the metatarsal bone and drawn hood-like over the capitulum when the toe is dorsally dislocated. If caught between the bones it might form a serious obstacle for the reduction. The thinnest part of the capsule is on the dorsal side. Here the basal phalanx easily penetrates through a rent of the fibers. (Fig. 3.)

The dorsal dislocation might also be produced by a *parallel shearing* force. This is the case in jumping upon some small object which protrudes from the ground and forces the phalanx straight up. As soon as the two bones which constitute the joint lose contact, the reflexory contraction of the tendons causes the overriding and shortening, thus making the dislocation complete.

Finally, we find either a fall straight forward or bumping the tip of the toe against a hard object as the cause. Schultze pointed out that the toes, in the event of a fall, are always in plantarflexion. Fixed by the action of the tendons the thin dorsal part of the capsule must give way. This accounts for the frequency of a dorsal deviation. Among ballplayers it is exactly the same mechanism which causes dislocations of fingers or a rupture of the extensor tendon.

Once the diagnosis is established reduction should be attempted as soon as possible. Contrary to fractures, the chance to accomplish a closed reduction dwindles rapidly as time elapses. The muscle spasm which serves as a natural defense against pain leads within a relatively short time to a contracture of the powerful flexor muscles. Here as in other dislocations the short-fibered muscles, originating or inserting close to the afflicted joint, show a rigid spasticity and very soon a true shrinkage of their length. In our case it is the flexor digitorum brevis as well as the lumbricales and interossei.

Even at an early stage the attempt at reduction might meet with considerable difficulty. The explanation may be found in some anatomical facts.

#### ANATOMY

The metatarsophalangeal joints are true *free joints* like the corresponding junctions of the hand, although their range of motion is far less. This fact is almost forgotten because their development and use among civilized races are impeded by the influence of footwear. There are, however, enough cases on record in which congenital or accidentnal loss of the upper extremities forced the use of the toes to almost finger-like dexterity through constant training.

The joint surface of the head of the metatarsus represents a spherical segment, while the base of the phalanx is much smaller and forms a transverse, shallow, oval-shaped, concave socket.

The capsule is very wide and slack. Its insertion is close to the cartilage on all sides, with the exception of the plantar side where it recedes about 5 mm. The dorsal part is very delicate and in close connection with the extensor tendon aponeurosis. The plantar part is reinforced to the so-called lamina fibrocartilaginea which arises from the rim of the basal phalanx, thus forming a lip to enlarge the concave socket. It contains the sesamoid bone or bones and is a continuation of the transversal ligaments between the metatarsal heads. It also forms

the upper wall of the sheath for the flexor tendons. (Fig. 3.)

Two strong collateral ligaments—one on either side like in a hinge-joint—originate from a distinct groove of the metatarsal head and extend fan-like to their insertion at the base of the phalanx. They are relaxed when the joint is straight, but due to their course and eccentric arrangement, become taut with increasing flexion. (Fig. 2.) Their plantar fibers are called ligamenta plantaria accessoria. If the dislocation is complete, the collateral ligaments clutch the wider part of the capitulum between themselves known as button-hole mechanism. Given sufficient time to shrink in this pathological position they can render reduction impossible. Another function of the collateral ligaments in the intact joint is to check the lateral movements of the toes when they are flexed. As can be better demonstrated on the fingers, abduction (spreading) is only feasible with the joints extended or slightly flexed, but is inhibited at 90 degrees flexion.

Active movements of the metatarsophalangeal joints comprise: plantarflexion, dorsiflexion (extension), adduction and abduction (spreading of the toes). Passively, a moderate degree of rotation is also possible.

The aforementioned fibrocartilaginous plate contains the sesamoid bone or bones. Two of them are regularly found under the basal joint of the big toe. One or two smaller ones are frequently seen on the fifth and less often on the fourth toe. In rare cases they may be present on all joints.\* In case of a dislocation they are important in so far as they might become interposed with the rest of the capsule and increase the difficulty of reduction. (Fig. 3.)

Other structures in close vicinity of the articulation comprise the tendon of the musculus interosseus dorsalis and plantaris and the tendon of the musculus lumbricalis.

\* I published a picture of supernumerary sesamoid bones on all toes bilaterally in 1932. Vide Roentgen-diagnostik der Knochenverletzungen. Vienna, 1932. Wilhelm Maudrich.

Each is separated from the bone by a small bursa. Another bigger bursa (intermetatarsophalangea) exists on the medial and lateral side of the head of the second, third and fourth metatarsus. Disregarding other muscles of minor importance like the abductor digiti quinti and the caput transversum of the abductor hallucis, there are at least an average of six to seven tendons around each joint. All the different textures are closely interwoven and connected by strands of ligaments. (Fig. 1.)

It is clear from this description that the interposition of one of the tendons is a frequent and most embarrassing complication. Similar to the buttonhole luxation of the thumb this incident may render all efforts futile. (Fig. 4.)

Thus it is apparent that this small and seemingly simple joint offers highly complicated conditions in case the normal relationship of these structures is disturbed.

Reduction, however, as a rule is easily accomplished, if the dislocated toe shows a deviation to the side or a rotation. For this is only possible, if one of the collateral ligaments is completely torn and thereby the interfering tension removed.

Either type has its advantages or disadvantages. As long as the collateral ligaments are intact, the joint shows no tendency to redislocate, because they reassume their rôle as a safeguard and lock. Reduction on the other hand is simple in case of a torn ligament, but the phalanx tends persistently to slip out of place.

#### TREATMENT

The *technic of reduction* follows the procedure employed in a common dislocation of the thumb, viz., hyperextension, distal pressure and finally flexion.

Difficulties may arise from the smallness of the toes which prevents a good grip and offers merely a short lever. The firmness of the surrounding structures, increased by hematoma and swelling, also impedes manipulation.

In order to provide a better grasp for the operator's fingers the skin should be daubed

with some glutinous stuff, a solution of mastix, e.g., and strips of adhesive tape applied. Often rubber gloves will suffice.

It must be emphasized that *proper anesthesia* facilitates the procedure and often means the balance between success and failure. Elimination of pain prevents the otherwise inevitable muscle spasm. Except with old, neglected cases *local anesthesia* with 2 per cent novocain is the anesthetic of choice. Fifteen to twenty-five cc. injected directly into the joint and neighborhood provide excellent conditions, because it makes the surrounding tissues more succulent and breaks up already formed adhesions.

As to the proper manipulation, simple longitudinal traction should always be tried first. Here, as in other instances, it is not so much a matter of rude force as of gentle pull for a *sufficient length of time*. The already shortened tissues must be given *time* to relax and stretch. If these rules are observed, the dislocated part often slides back into place so gently that it is hardly noticeable. Only the normal appearance and the free motion testify to the results which ought to be checked immediately by x-ray.

If mere traction does not prove successful, rotation might be tried in order to free some interposed tissue. At last the classical way of hyperextension and distal pressure should be attempted. If for some reason the operator fails to get a good grip with his fingers, he can replace them temporarily either by a loop of twine or by the ring of a key which provides an excellent lever.

After successful reduction the joint should be immobilized in order to allow undisturbed healing of the torn tissues. For a patient confined to bed because of other injuries, strapping with multiple layers of adhesive tape is sufficient, provided the adjoining toes are included as a splint. A small pad should be placed beneath the head of the second and third metatarsal bone to preserve the transverse arch. If, however, the patient is ambulatory from the very beginning, immobilization by



means of a carefully molded plaster of paris cast is indicated. The duration of the necessary immobilization depends especially on

original place. In old cases the dislocation can often be reduced in the open wound by digital pressure, but it has a tendency to



FIG. 5. Dorsolateral dislocation of fourth and fifth toe (Case 1) before and after reduction. Note the wide space between the fourth and fifth metatarsal bone as a consequence of their ruptured intermetatarsal ligaments.

the age of the patient, the type of dislocation and other injuries of the bones. The average time is about three to five weeks. A prolonged time of initial fixation will be well compensated for by the absence of pain or other ill after-effects.

Operative intervention may become necessary in case the closed reduction fails.

Since plantar scars should be avoided whenever possible, preference is given to a dorsal or laterodorsal incision. Although the operation might be done very well under local anesthesia, the use of a general anesthetic is sometimes advisable. It permits the application of a tourniquet, thus giving better view to identify the different structures. Besides it is occasionally helpful to apply traction to the toe by means of a stainless steel wire passed through the tip of the phalanx.

After removal of the surrounding scar tissue the ends of both bones are thoroughly freed and mobilized. Sometimes this is possible only after severance of the shortened lateral ligaments and excision of the torn joint capsule. Any incarcerated tendon should be freed and put back in its

redislocate as soon as the pressure is released. The resection of the base of the phalanx has to be resorted to unless the corrected position can be maintained by using chromic catgut. No attempt is made to form or restore the excised capsule as it will be replaced by connective tissue. After closure of the wound a well molded dorsal and plantar plaster of paris splint is applied, exerting just enough pressure to maintain the position. The patient is kept in bed at least until the skin is well healed. Radiographs after one or two weeks are essential to make sure that the dislocation does not reoccur. Then the patient is permitted to walk with a well fitted cast.

Old, unreduced dislocations produce an increased diameter of the foot in the dorso-plantar direction due to the overriding of the bones. At first, the prominence is found over the dorsum corresponding to the displaced base of the phalanx, but as the patient walks about the pressure from the shoe forces the protruding toe down to the level of the others, pushing the head of the metatarsus underneath out of its place toward the sole. The ensuing complaints

are the same as in a case of metatarsalgia following a severely flattened transverse arch, such as constant pain, corns, bursitis

The lateral view was interesting in so far as it showed clearly the dorsal dislocation of the fifth toe. The outline of the fourth metatarso-



FIG. 6. The same case as in Figure 5, lateral view before and after reduction. Due to superimposition of the bones the dislocation, especially of the fourth toe, might be easily overlooked.

or even deep pressure sores. The resection of the base of the phalanx generally brings relief.

#### CASE REPORTS

**CASE I.** A fifty-five year old carpenter fell from a roof about 9 feet high on uneven, soft ground. He suffered a concussion of the brain and a fracture of the elbow, as well as lacerations about the face and multiple bruises. When first seen he was in shock and in a semiconscious condition. Due to the head injury he had a retrograde amnesia, therefore, nothing could be learned as to the mechanism of the trauma. Within the following days his general condition improved. Then the patient began to complain of pain in his left foot. Examination revealed a deformity at the base of the fourth and fifth toe. In spite of the already present swelling a probable diagnosis was made of dorsal dislocation of these two toes, which was confirmed by a subsequent x-ray film.

The dorsoplantar picture shows the fourth toe the full width of the base laterally displaced, while the fifth toe is only partially dislocated to the lateral side. The overlapping with the heads of their respective metatarsals can readily be seen.

The first glance revealed that the distance between the fourth and fifth metatarsal bones was unusually wide as compared to the others. It conveys the impression that the phalanx of the fourth toe had been driven like a wedge between these two bones. This, of course, was only possible if the transverse intertarsophalangeal ligaments were torn. (Fig. 5A).

phalangeal joint, however, was so difficult to distinguish from the other bones that the deviation was hardly discernible. This was an excellent example of how easily an injury might be overlooked, as I mentioned on a previous occasion. (Fig. 6A.)

At this time an attempt at reduction without anesthesia met with failure due to pain and reflectory muscle spasm. Ten days after the injury the patient had improved so much that an open reduction was considered under local anesthesia because of a chronic myocarditis.

Infiltration with 20 cc. of 2 per cent novocain solution produced perfect anesthesia and relaxation. Thus with the patient on the operating table and everything prepared for surgery, once more a closed reduction was attempted.

Using rubber gloves made it easy to get a good grip. The toes slipped back into place with a slight snapping sound as soon as sufficient pull was exerted. An x-ray picture confirmed the reduction. (Figs. 5B and 6B.) Since the patient was confined to bed because of his other injuries, the two joints were immobilized with a few layers of adhesive tape around the forefoot.

Recovery was uneventful. The foot was supported by adhesive strapping and walking was begun four weeks following the injury. After ten months there was complete function without any pain or discomfort.

**CASE II.** A thirty-nine year old bricklayer, while working on a scaffold about 6 feet high, lost his balance and was forced to leap, landing on his feet. As he struck the ground which was littered with fragments of brick, he felt a sudden pain in his left foot. Afraid of losing the job he had just secured, after a long time of

unemployment, he disregarded the injury and kept on working. The first few days after the accident walking was difficult due to considerable pain, but this condition improved steadily after one week. As the acute swelling gradually subsided he noticed a distinct shortening of the second toe and a deformity at its base. Eight weeks later he had no noticeable discomfort, but could feel a hard prominence on the sole of his foot. During the following months, however, the constant pressure over this area developed an increasing painful bursitis which finally forced him to seek medical aid.

The clinical picture was very indicative of an inveterate dorsal dislocation of the second toe. The skin of the dorsum still showed moderate edema with obliteration of the normal wrinkling and the sharp delineation of the interdigital folds. The head of the second metatarsal bone was prominent and palpable from the plantar side. The toe itself was dorsiflexed and looked almost like a hammer-toe. Passive motion of the metatarsophalangeal joint was restricted to a few degrees, so that it had to be considered as a fibrous ankylosis. The x-ray picture revealed a complete dorsal dislocation with considerable shortening and overlapping.

Under these circumstances a closed reduction was out of question and the patient consented to an operation.

With a tourniquet applied the joint was freely exposed by a 3 inch dorsal incision. The ends of both bones and the former joint space were found covered with dense, fibrous scar tissue which had to be removed by sharp dissection. Only after severance of the collateral ligaments on both sides could the basal phalanx be moved at all. The cartilage of the joint surfaces was well preserved and shiny. The plantar part of the capsule with the fibrocartilaginous plate was pulled over the head of the metatarsus, causing a real interposition. This disc-like piece was on both sides in connection with the lateral ligaments, apparently by secondary

adhesions. After excision of this part, the phalanx could finally be reduced with some difficulty and held in place by digital pressure. Upon releasing the pressure, however, the toe snapped back into the dislocated position. Therefore the proximal half of the basal phalanx was resected, thus securing good alignment and straightening out the toe immediately. At the same time the head of the metatarsus which had been displaced by the pressure of the dislocated toe, could be lifted easily to the level of the neighboring metatarsal bones, restoring the normal transverse arch of the foot.

The patient made an uneventful recovery and returned to work after five weeks with full function of the foot.

#### SUMMARY

1. Dislocation of one or more toes in the metatarsophalangeal joint is rare and, therefore, often not diagnosed.
2. The anatomy of the joint structures and their relationship to the mechanism of the dislocation is reviewed.
3. The method of closed reduction in simple cases is described. Operative procedures for nonresponding cases and old dislocations are discussed and an example for each is given.

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# UNUNITED FRACTURES OF THE CARPAL SCAPHOID\*

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CONSIDERABLE differences of opinion exist in regard to the therapy of ununited fractures of the carpal scaphoid. In principle, the treatment has varied from the most conservative type of prolonged immobilization to the most radical excision of the whole proximal row of carpal bones. Prolonged immobilization, excision of one or both fragments, excision of the whole proximal row of carpal bones, fusion of the fragments by means of bone graft<sup>1</sup> and even fusion of the wrist<sup>4</sup> have all been recommended and each has been attended with varying success.

In recent literature<sup>3</sup> the tendency has been to discard the mutilating excision operations and rely more on fusion between the fractured fragments. It may be doubted whether the satisfactory outcome in this latter method is due to the bone graft or to the drilling which is a necessary prelude to the insertion of the bone graft. If, as Bohler believes, simple drilling is sufficient, considerable operative manipulation could be avoided. In this light the following two cases may prove interesting:

## CASE REPORTS

CASE I. S. B., a white male, nineteen years old, fell on his left hand February, 1939. X-rays taken at that time were reported negative for fracture. He was again seen in December, 1939, ten months after the injury, because of a dull ache in his left wrist. X-rays at this time revealed cystic changes along the line of fracture. His left wrist was immobilized in a circular plaster of paris cast for about nine weeks. Repeated roentgen studies failed to reveal any bony union of the fragments. Upon removal of the cast February, 1940, he complained of weakness of the wrist and tenderness in the "snuffbox." Examination revealed a

slight atrophy of the left lower forearm and hand and considerable limitation of dorsal and volar flexion of this wrist. The right forearm and wrist were normal. X-rays (Fig. 1) at this time showed a fracture of the left scaphoid with no appreciable separation of the fragments. On February 27, 1940, under tourniquet above the elbow, an incision was made in the anatomical snuffbox. The extensor pollicis longus was retracted medially and the scaphoid bone was exposed. Several drill holes were made from the tuberosity proximally. After wound closure, immobilization was effected by a circular plaster of paris cast with the wrist in marked extension and radial deviation.

The postoperative course was uneventful and the patient left the hospital March 2, 1940. The cast was not removed until April 26 (eight and one-half weeks postoperatively) when the x-ray examination (Fig. 2) showed bony union. Stereoscopic examination May 7, 1940, showed union. Check-up examination on November 19, 1940, showed that the patient had a good grip, he could flex and extend this wrist almost as well as the other wrist. He was able to resume his usual work. He could lift things with this hand if they were not too heavy (he lifted a chair without experiencing any pain at the wrist). X-rays showed bony union.

CASE II. S. S., a white male, seventeen years old, fell on his left hand about the middle of January, 1940. X-ray showed a fracture of the scaphoid. He was properly immobilized in a circular cast for six and a half weeks. Upon removal of the cast there was pain and weakness of grip and limitation of flexion and extension of the left wrist. X-rays (Fig. 3) showed that the fracture was still present. The same operative procedure as in Case I was performed April 4, 1940, and a cast similarly applied. The patient was discharged from the hospital April 9, 1940, and the cast was removed about ten weeks postoperatively. X-rays (Fig. 4) showed good bony union. Check-up examination on

\* From the Services of Dr. E. D. Oppenheimer, Beth Israel Hospital, and Dr. H. Milch, Hospital for Joint Diseases, New York City.



FIG. 1. Case 1. Shows fracture of left scaphoid.



FIG. 2. Case 1. Shows bony union.



FIG. 3. Case II. Shows fracture of left scaphoid.



FIG. 4. Case II. Shows bony union.



FIG. 5. Case III. Shows fracture of right scaphoid.



FIG. 6. Case III. Shows ununited fracture of scaphoid.

October, 30, 1940, revealed that this patient had no pain in the left wrist, although before the operation pain was present even when resting this hand. Flexion and extension were a few degrees less than the opposite side. The grip was good now whereas before the operation it was weak. He casually mentioned that he played handball a few days after the removal of the cast and shortly thereafter he rode a bicycle and played association football.

Although these two cases demonstrate that satisfactory union may be secured by simple drilling, it is not intended to indicate that drilling, or any other surgical procedure is absolutely indicated once the diagnosis of nonunion has been made. In all instances the clinical picture must be considered paramount. In an earlier article<sup>5</sup> attention was called to the fact that in acute fractures of the navicular, greater reliance was to be placed upon the clinical picture than upon the negative result of a roentgenogram. Similarly, the indications for therapy must depend more on the patient's disability than upon the simple roentgen demonstration of the absence of union. In fact some cases of established non-union of the carpal scaphoid require no treatment whatsoever, as the following case demonstrates:

CASE III. S. H., a white male, thirty-five years old, was struck on the right wrist by some lumber November 15, 1933. When seen three weeks later, the examination and the x-rays (Fig. 5) pointed to the diagnosis of a fracture of the right carpal scaphoid. Immobilization by means of a circular cast was maintained for six weeks. He returned to work about four months after the injury. A year later, in December, 1934, he was exhibited at an orthopedic meeting. X-rays (Fig. 6) at that time showed no union and some osteo-arthritic changes of the lower end of the radius. However, the patient was able to paint walls with his right hand

which requires considerable wrist motion. After the patient left the meeting, several surgeons criticized the treatment and prognosticated that this wrist would become more painful and that the function would be further impaired. They advised removal of one or both fragments. They based their remarks on the fact that the second set of films showed more pathological changes than the first.

This patient returned to my office recently for another condition, about seven years after the injury, which is six years after the meeting at which he had been presented. He stated: "I do heavy lifting, have no pain, no funny feeling, and no difficulty in using this wrist. It has never troubled me since you discharged me about six and a half years ago." Examination showed a strong grip; flexion of the wrists were equal; extension was a few degrees less on the right side as compared to the left. X-rays taken September 7, 1940, showed no evidence of bony union (x-rays of the opposite wrist were negative for fracture of the scaphoid).

#### CONCLUSION

1. The prognosis as to function and the question of further treatment for ununited fractures of the carpal scaphoid must be based on clinical findings rather than on roentgen films.

2. If pain and weakness of grip persist for months or longer after injury, firm bony union may be expected from the simple method of drilling.

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# MECKEL'S DIVERTICULUM\*

## WITH A REPORT OF TWELVE CASES

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**M**ECKEL'S diverticulum is not a rare congenital abnormality, however, the complications of this lesion are of such gravity that the subject is always of importance in any consideration of acute abdominal emergencies. The cases to be reported here illustrate well some of the more serious complications of this anomaly and it is believed that only by keeping such facts constantly in mind may we hope to reduce the mortality of such lesions.

The first extensive study of this anomaly was made by John Frederick Meckel in 1812.<sup>15</sup> The condition, however, had been mentioned in the literature in 1672 by J. H. Lavater<sup>13</sup> and in 1701 a good illustration of the diverticulum was given by Ruysch.

The earlier literature called attention to intestinal obstruction secondary to the anomaly. Later, peritonitis resulting from diverticulitis was reported and it has been comparatively recently, since 1925,<sup>18</sup> that ulceration and hemorrhage resulting from heterotopic gastric tissue in a diverticulum has been adequately studied.

Meckel's diverticulum is generally believed to occur in about 2 per cent of all individuals.<sup>9</sup> Most writers believe that it is usually four times as frequently observed in males as females.<sup>12</sup> Complications arising from the presence of the anomaly have been variously stated as occurring in 15 to 25 per cent of all cases when the diverticulum is present.<sup>3</sup>

The anomaly most often manifests itself as a blind pouch extending from the antimesenteric border of the ilium located from 12 to 36 inches above the ileocecal valve. In

the infant it is usually about 12 inches from the cecum while in an adult the distance is usually greater.<sup>4</sup>

The other relationships of the diverticulum may likewise vary. It is usually on the antimesenteric border, but may be present at other locations and in some instances emerges from the mesenteric side of the ilium. Likewise, while it usually has no mesentery, it may be supplied in its entirety by such a structure. The diverticulum is normally composed of the same three layers which make up the ilium, but at times contains heterotopic tissue simulating the mucosa of the stomach, duodenum, colon or pancreas.<sup>5,11,19</sup>

An understanding of the embryology of Meckel's diverticulum is essential for a proper appreciation of the most frequently observed complications. There is a wide communication between the embryo and the yolk sac early in fetal life. By the fourth week of fetal life this communication has narrowed down to a tubular structure known as the omphalomesenteric duct. In normal development the duct becomes a fibrous cord between the umbilicus and the bowel, then breaks, after which both ends are absorbed.

Should development fail to follow the normal pattern, any one of several abnormal conditions may result. As a rule, these abnormalities fall into one of the three forms: (1) The connection between the umbilicus and the intestine may persist in the form of a fibrous band or as an intestinal fistula. (2) The umbilical portion of the duct may persist. (3) The intestinal portion of the duct may persist.<sup>7</sup>

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## COMPLICATIONS

Meckel's diverticulum attracts the attention of the surgeon as a rule only when one of the several complications of this anomaly develop. These include: (1) intestinal obstruction, (2) diverticulitis, with or without perforation, (3) ulceration from heterotopic gastric tissue and hemorrhage from heterotopic gastric tissue, (4) intussusception, (5) foreign body, and (6) neoplasm.

The first three complications listed are responsible for by far the greatest number of abdominal emergencies associated with Meckel's diverticulum.

The earlier literature stressed the likelihood of intestinal obstruction resulting from a band, a volvulus or even intussusception producing obstruction. A band adhesion may extend from the diverticulum to the umbilicus or it may be attached to another loop of bowel or to the mesentery. Volvulus may occur resulting in obstruction. Reginald Fitz<sup>8</sup> summarized the American literature in 1884 and reported thirteen cases. He was impressed with frequency of obstruction as a complication and considered the question of diverticulitis as well, though it was absent in his cases. It is interesting that inflammation in a Meckel's diverticulum was appreciated and apparently given more attention before 1886 than was inflammation of the appendix, a far more common lesion.

Wolfson and Clurmann<sup>21</sup> recently attempted to differentiate between acute diverticulitis due to Meckel's diverticulum and acute appendicitis, reporting that in the former the pain is apt to be more severe and characterized by colic, the vomiting more pronounced and distention present in a higher percentage of the cases. Since acute appendicitis, a far more common lesion, may present such widely varied pictures, the author agrees with most writers on the subject in believing that the preoperative diagnosis of Meckel's diverticulitis is always very uncertain in cases in which appendectomy has not been previously performed. When perforation oc-

curs secondary to diverticulitis or from a perforated peptic ulcer, peritonitis either general or local must, of course, result. Due to its location an acute perforation of a Meckel's diverticulum would seem less likely to become walled off than would a perforated appendix.

Probably in a number of the earlier reported cases of perforated Meckel's diverticula due to diverticulitis the true cause was an unrecognized perforated peptic ulcer. In 1904, Salzer<sup>17</sup> described gastric mucosa in a Meckel's diverticulum which had prolapsed through the umbilicus. It remained, however, for Schaetz, in 1925, to focus attention on the similarity between peptic ulcers of the stomach and duodenum and those occurring in Meckel's diverticula.<sup>18</sup> He found gastric mucosa in five of thirty cases of perforations of diverticula. Likewise he called attention to the frequent hemorrhages per rectum in such cases. Since this the question has received far more attention.

Brennemann<sup>2</sup> has pointed out that the blood per rectum originating in a Meckel's diverticulum usually contains clots while that from an intussusception or from ilio-colitis usually does not. Abt and Struss<sup>1</sup> emphasized the importance of a Meckel's diverticulum containing heterotopic tissue as a cause of rectal bleeding in children after other more common causes have been eliminated. They successfully operated on three such patients before perforation occurred.

Dragstedt<sup>6</sup> emphasized the importance of hydrochloric acid in the production of the peptic ulcers of Meckel's diverticula. The experimental work of Matthews and Dragstedt<sup>14</sup> on ulcer showing that the small bowel becomes progressively more sensitive to gastric juice as the distance from the stomach increases agrees with the clinical finding that such ulcers are quite likely to perforate.

Schullenger and Stout<sup>19</sup> pointed out that gastric mucosa may be present in a diverticulum and may be responsible for



bleeding or ulceration and yet be recognizable only on careful microscopic study.

Aberrant pancreatic tissue in a Meckel's diverticulum was recognized in 1861 by Zenker<sup>22</sup> though it occurs far less frequently than does aberrant gastric tissue. Hunt and Bonesteel<sup>11</sup> carefully reviewed the subject studying thirteen cases from the literature and adding one of their own.

Mucosa simulating that normally found in duodenum and colon have likewise been reported. Numerous explanations have been offered for the presence of such misplaced tissue. None of the theories advanced seem entirely satisfactory.

Meckel's diverticulum has been known to be one of the causes of intussusception since 1846. Harkins has studied the subject

extensively reviewing 160 cases from the literature and reporting two of his own. He emphasizes the importance of early diagnosis and immediate operative treatment of the condition.<sup>10</sup>

#### COMMENT

The patients whose cases are reported in Table I were operated upon at the John Gaston Hospital by various members of the surgical staff of the University of Tennessee between 1924 and 1941. Some of the patients were operated upon by the resident surgeon and others by members of the attending staff.

The greater incidence of the condition in males in this series agrees with the findings generally recorded by other writers with

TABLE I  
SUMMARY OF CASES REPORTED OF MECKEL'S DIVERTICULAS

No.	Sex	Age	Race	Admission Complaint and Findings	Preoperative Diagnosis	Postoperative Diagnosis	Operative Procedure and Result
1	M	8	C	Epigastric pain, nausea, vomiting, distention, tenderness in epigastrium. Symptoms for 48 hrs. T. 100.4°F., w.b.c. 8,600	Obstruction with peritonitis	Obstruction band, from diverticulum to umbilicus	Band divided, diverticulum excised; recovery
2	M	35	C	Peri-umbilical pain, vomiting, diarrhea. Tenderness R. L. Q. 24 hrs. duration. T. 100°F., w.b.c. 11,400	Acute appendicitis	Acute Meckel's diverticulitis	Diverticulum excised; appendectomy; recovery
3	F	8	C	Umbilical pain, constipation, vomiting, 4 days duration. T. 100.4°F. w.b.c. 10,000	Intestinal obstruction	Complete obstruction by band from Meckel's diverticulum	Band excised; diverticulum excised; ileostomy; death
4	F	19	W	Lower abdominal pain, nausea and vomiting. Tenderness in R. L. Q. 24 hrs. duration. T. 96°F., w.b.c. 27,600	Acute appendicitis or torsion of ovarian cyst	Intussusception of Meckel's diverticulum	Intussusception reduced; diverticulum excised and appendectomy; recovery
5	M	45	C	R. L. Q. pain, nausea, vomiting, tenderness, and rigidity 24 hr. duration. T. 98.2°F., w.b.c. 7,500	Appendicitis	Chronic appendicitis. Meckel's diverticulum not inflamed	Appendectomy; 1 month later diverticulum removed; recovery
6	M	5	W	Peri umbilical pain, vomiting, 5 days duration. T. 98.2°F., w.b.c. 10,050	Intestinal obstruction	Obstruction by band to umbilicus from acute Meckel's diverticulitis	Band excised; diverticulum, acute, excised; recovery
7	M	35	W	R. L. Q. pain, tenderness. 24 hr. duration. T. 99.6°F., w.b.c. 14,000	Acute appendicitis	Acute Meckel's diverticulitis	Diverticulum excised; appendectomy; recovery
8	M	17	W	Cramping abdominal pain, vomiting, slight distention. 36 hr. duration. T. 99°F., w.b.c. 6,800	Intestinal obstruction	Obstruction by adhesive bands above diverticulum	Bands resected; diverticulum excised
9	M	9	W	Peri-umbilical pain, nausea, vomiting, tenderness, and rigidity in R. L. Q. 5 hrs. duration. T. 102°F., w.b.c. 10,450	Acute appendicitis	Acute appendicitis and acute diverticulitis	Appendectomy; diverticulum excised; recovery
10	F	14	W	R. L. Q. pain, duration 4 hrs. w.b.c. 8,500. T. 99.2°F.	Acute appendicitis	Diverticulitis, normal appendix	Appendectomy, diverticulum excised; entero-enterostomy; recovery
11	M	61		Epigastric pain localizing about umbilicus, vomiting, duration 6 hrs. Tenderness, slight rigidity. T. 98°F., w.b.c. 9,950	Acute appendicitis	Acute diverticulitis	Excision of diverticulum; appendectomy; recovery
12	M	16		Epigastric pain 12 hrs. duration. Tender mass in R. U. Q., T. 98°F., w.b.c. 12,200	Intestinal obstruction	Intestinal obstruction from band, gangrenous diverticulitis	Resection of band; excision of diverticulum; appendectomy; recovery

reference to sex. Half of the cases were found in adults. Much attention has been called to the complications of Meckel's diverticulum in childhood; and while such studies are entirely appropriate, it must be borne in mind that these complications must also be considered in adults.

Intestinal obstruction was present in four cases, acute diverticulitis in four, both obstruction and diverticulitis in one, intussusception in one, and in two cases the diverticulum was only subacutely or not at all inflamed. Death occurred in only one case, this being a patient who had suffered from intestinal obstruction for four days prior to admission.

In spite of the very satisfactory outcome of eleven out of twelve cases, in no instance was Meckel's diverticulum diagnosed preoperatively. The important fact obviously is that an acute condition of the abdomen was promptly diagnosed and laparotomy carried out.

No heterotopic tissue was found on examination of these specimens. However, without making several sections from each case such tissue might readily be missed as is seen from the work of Stout.

Granted that the most important factor in the proper management of this group of patients is early recognition of an acute condition of the abdomen followed by laparotomy, the judgment shown by the surgeon at operation is also definitely significant in determining the final result. The operative procedure used must of necessity vary with the findings in the individual case.

When intestinal obstruction is found, this must be relieved by appropriate surgical measures. If the patient is operated upon relatively early and a band is found, the diverticulum may be resected at the same time that the band is divided. If the bowel has been distended to a marked degree and the patient is acutely ill, it is far better judgment to do only enough to abolish the obstruction since leakage is more apt to occur in the bowel which has recently been damaged by severe disten-

tion. The longer operation also increases the hazard to the seriously ill patient.

Frequently, the diverticulum is resected and the defect closed by two rows of sutures or by a purse string. The broad base usually present in such cases requires care that the lumen after resection and closure will not cause obstruction. Since aberrant gastric mucosa may be present at the base as well as in the more distal portions of the diverticulum and since such tissue may not be apparent from gross examination, it is important to resect the entire diverticulum otherwise one might leave enough gastric mucosa to produce bleeding or perforation at a later date.

The method of inverting the diverticulum occasionally advised in the literature seems unwise since it not only does not remove potential aberrant tissue but also might be the means of causing obstruction or intussusception.

#### SUMMARY AND CONCLUSIONS

1. The common complications of Meckel's diverticulum resulting in acute abdominal emergencies are reviewed.
2. Twelve cases with one death are reported and subjected to analysis.
3. Early diagnosis of an acute condition of the abdomen followed by appropriate surgery offers the best opportunity for recovery in these patients.
4. A careful search should always be made for a Meckel's diverticulum in cases in which the operative findings do not explain the preoperative symptoms or the peritonitis encountered at laparotomy.

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THE effect of morphine on the intestine seems to vary with conditions, but according to Paine, et al., the drug uniformly enhances both the tone and the peristaltic activity of the intestine, both normal and obstructed. From—"Surgical Physiology"—by Joseph Nash (Charles C. Thomas).

# FIBERGLAS SUTURE MATERIAL

## PRELIMINARY REPORT

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FIBERGLAS suture material<sup>1</sup> has all the requisites laid down by investigators from the time of Kocher<sup>2</sup> and Halsted<sup>3</sup> to those of the present day. As its name implies, the suture material is made of glass filaments, drawn to such fineness that 204 filaments must be combined to make a strand measuring 45,000 yards per pound. Its extreme tensile strength makes possible the use of a very fine, yet strong suture. To the sense of touch and in appearance it is like the finest silk and can be handled like silk, holding its knot perfectly. Experience has taught, and Ballas<sup>4</sup> has stated in his recent publication, "that glass is among the least reacting substances in tissue." Because Fiberglas is inert and nonreacting in the tissue, and practically nonsoluble, it does not cause exudation, edema, or cell proliferation; and it in no wise interferes with wound healing. Healing of wounds takes place without any puffiness and little or no swelling.

Fiberglas does not elongate, neither does it shrink; but when braided, the braiding affords a little give. It is not affected by tissue fluids, enzymotic action, or action of chemicals; neither does it produce toxins, or allergic reaction. The fact that each fiber is an extremely fine, solid filament of pure glass, makes it nonabsorbent, and in view of its being a nonirritant, it does not call forth tissue fluids which would harbor germ life, nor do bacteria attack it. The fact that it is nonsoluble precludes the formation of harmful biproducts. Glass is not classed as a carcinogenic substance.

During the past two years we have been using Fiberglas suture material experimentally both in human beings and in

animals. In quite a few clinical instances we have left buried sutures which remain to date with no untoward effect. Dogs, too, have retained buried sutures without any local reaction. (Our use to date of Fiberglas suture in the human has been confined to surgery of the head and neck.)

In contradistinction to some of the more recent suture materials put on the market, we wish to emphasize that Fiberglas is not an organic plastic but real glass and thus inert. Its composition is known to the manufacturer as type "E." The tensile strength of a "12 braider tube" Fiberglas suture (approximately the size of No. 00 silk, which breaks at 7.4 pounds) is approximately 9.44 pounds; knot strength is approximately 4.41 pounds, loop strength approximately 8.1 pounds, showing Fiberglas to be much stronger than silk. It is sterilizable by all methods: autoclaving, boiling, dry heat (well below softening or melting point of glass); by chemicals (except hydrofluoric acid); and it bears repeated sterilization perfectly.

In our experiments on dogs, ten sutures of "12 braider tube" Fiberglas yarn were placed in the skin at three-day intervals. Then a strip of skin an inch wide containing the ten sutures was removed for study. The resulting wound was again closed by sutures, half of which were removed with the tissue surrounding them after three months. The others were allowed to remain for the future. It was to be expected that difficulty would be encountered in sectioning the tissue containing the Fiberglas yarn, because of the frangibility of glass. Many specimens were prepared and mounted in paraffin. Hundreds of sections were made in the

hope that in spite of that obstacle we would be able to show Fiberglas suture in a section of tissue. But invariably as the

shows the section of a knot of Fiberglas outside of the skin, mounted in paraffin. These sutures had been *in situ* for twenty-

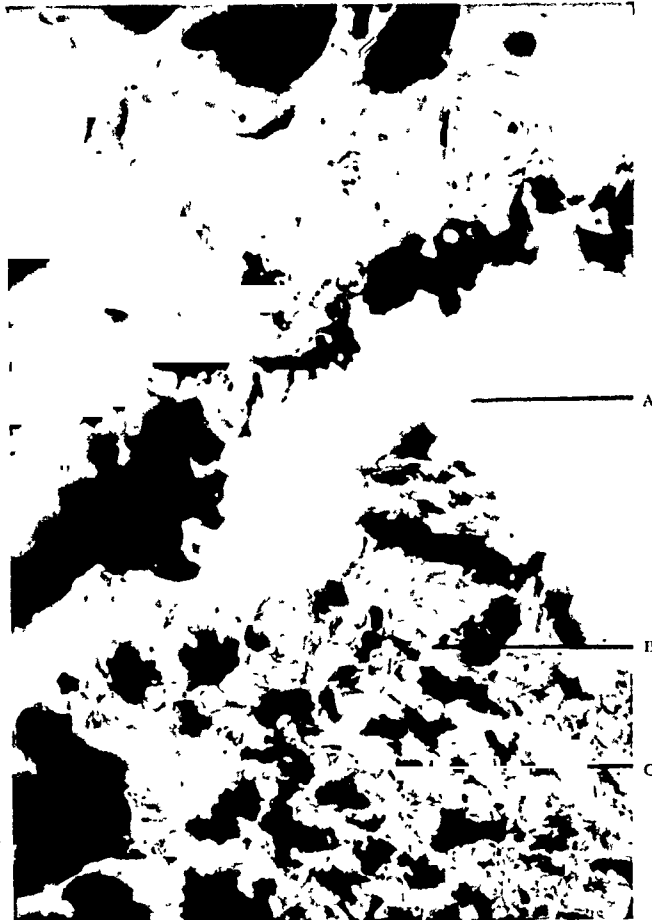


FIG. 1. Specimen of dog skin prepared and mounted in paraffin and stained with eosin. A, cutting artifact; B, fiberglas suture in cross section; C, the black particles intermingled with the glass fibers in the picture are eosin-stained animal particles and not cellular infiltration.

microtome blade cut through the suture, the tiny glass disks scattered throughout the field; or where the glass offered more resistance to the blade, tore their way through the tissue. A thorough study of the tissue so damaged in sectioning failed to show signs of irritative or inflammatory changes, as is shown in Figure 1. Figure 2\*

\* Gradwohl Laboratories (Pasteur Institution), St. Louis, Missouri. January 30, 1942.

"All these specimens show the presence of the suture, but they were broken up by the cutting edge of the microtome, and the tissue showed no irritation from the presence of such suture material." R. B. H. Gradwohl, Director.

two days. Apparently the paraffin affords more support to the suture while it is being cut than does the tissue, even though the latter is impregnated with paraffin.

Fiberglas suture material has been so satisfactory in our hands in the past several years that we believe it is worthy of extensive trial and intensive study by others. It is regrettable that we were not able to show the suture in place in the tissue; possibly someone else will be more successful. In a subsequent report we hope to show Fiberglas suture which has been in

the tissue for a longer period, and to demonstrate the effect it has on tissue when imbedded in it for a long time.

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FIG. 2. Section of knot of Fiberglas suture tied outside of dog skin prepared and imbedded in paraffin and stained with eosin. A, suture in longitudinal cut; B, suture in cross cut.

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# THE VALUE OF CYSTOSCOPIC PHOTOGRAPHY IN MEDICINE\*

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THE value of cystoscopic photography in the practice of medicine, from the standpoint of the urologist, the surgeon or the internist, is incalculable. It is only in recent time that it has been possible to apply photography and photographic equipment in conjunction with the use of the cystoscope. Since the dawn of civilization, man has consistently attempted to examine, explore and perfectly describe the detailed anatomy and pathological lesions in the various body cavities and normal body sinuses. Urological equipment has done much toward this advancement.

Commercially, there are several instruments advanced, both in America and abroad which, unfortunately, could not be satisfactorily operated by the author. It was only after many years of research and experimentation with cystoscopic photography that the author, working in conjunction with optical engineers and expert machinists, was able to produce an instrument capable of photographically recording the normal anatomy and pathological lesions of the bladder, as visualized through the cystoscope. It is for this reason that such an extensive and elaborate study of optics, as applied to cystoscopy, was undertaken. The camera used and herein described is original.

The lens system of the camera is a complete unit in itself and is used for one purpose only, photography. It cannot be used routinely, by itself, for any cystoscopic examination or procedure, but in conjunction with the camera, presents a perfect photographic image. It is so designed as to accurately lock into a position in a standard Brown-Buerger cystoscope, No. 24 F.

The camera is of reflex type in that, by a series of lenses and mirrors, the latter made of stainless steel alloy and highly polished, the entire vesical cavity may be examined or photographed. Being of a reflex type, the main mirror of the camera also acts as a shutter, so that the portion to be photographed may be observed up to the time of the photographic exposure. At the moment of making the photographic exposure, the mirror is thrown out of position, allowing the light rays to continue in a straight line to expose the photographic negative. After exposure of the photographic negative, the mirror again falls back automatically into its original position, so that continued observation or photography may be accomplished without manipulation of the instrument.

The lighting equipment is that of the standard Brown-Buerger cystoscopic sheath. The light is stepped up by a delicate rheostat to a point of maximum intensity at the moment of making the photographic exposure.

The film used for routine work, producing a black and white photograph, is a standard Super-Ortho Chromatic Press, having a Weston light rating of 32, (Tungston). An individual cut film is used for each exposure. By using an individual cut film, it is possible to develop the films individually of any given instance in which photographs are taken, whereas with the use of roll film, it would necessitate a complete exposure of the film before developing. By the use of the individual cut film it is often possible to re-photograph a given lesion before any alteration of the pathological appearance, particularly once treatment has begun. The time of an exposure

\* Presented before the Philadelphia Urological Society, November 25, 1940.

of a black and white negative varies materially with the reflective qualities of the mucous membrane of the bladder. A clear,

from perfect. The Kodachrome photographs produced exhibit an excess of yellow. This is attributed to the fact that

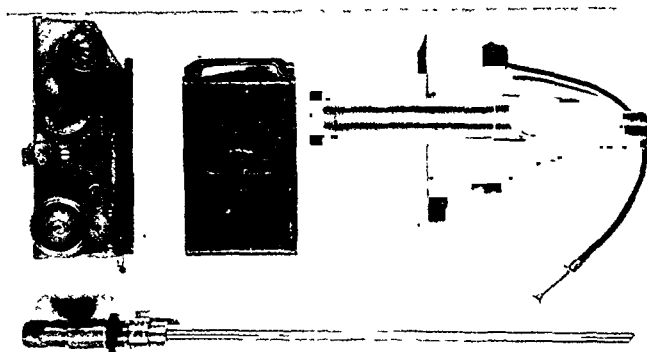


FIG. 1.

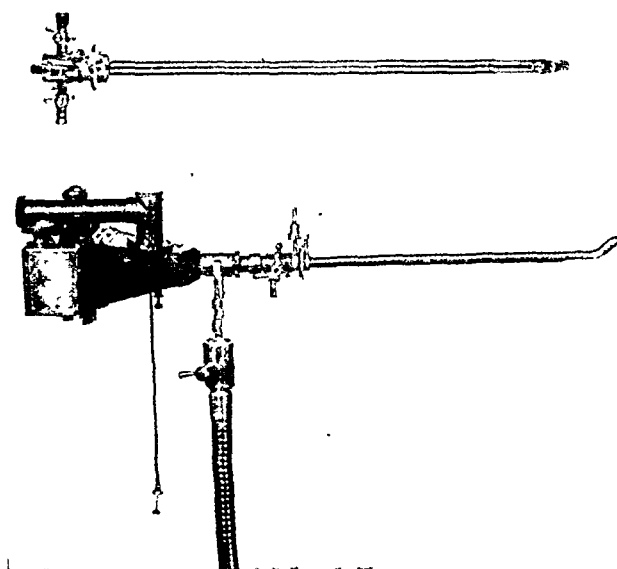


FIG. 2.

FIG. 1. The component parts of the photographic equipment. A standard Brown-Buerger No. 24 cystoscopic sheath is utilized, which holds an especially devised photographic lens. The camera (upper right) is of a reflex type and uses both an individual cut film for a black and white photograph, or an adapter for Kodachrome.

FIG. 2. Complete assembly of the photographic equipment.

glistening, normal appearing mucosa will reflect the light with a greater intensity and greater speed, thereby shortening the time of exposure, in contrast to a bladder mucosa that is highly inflamed in the presence of an acute cystitis. There is no set rule followed in making the exposures; one's own judgment and experience is used rather than a mechanical estimation of an exposure.

Our use of Kodachrome has been quite unsatisfactory. The photographic image produced is one of definite sharpness, but the rendition of color value is one that is far

the bladder mucosa, under normal conditions, is quite yellow and the usual cystoscopic light has a considerable yellow quality. Due to these facts, the results have shown a predominance of the yellow factors of the spectrum, which is decidedly not an accurate rendition of color tones and values. Further experiments are being conducted in the hope that true color values may be attained.

The value of a photographic record of any given lesion, particularly carcinoma of the bladder, is inestimable. It has been the practice of all urologists to describe the



pathological appearance of a given lesion very carefully, also giving its description following subsequent cystoscopies. The

a different angle observed by the artist than when observed by the cystoscopist.

To be able to photograph a definite

FIG. 3.

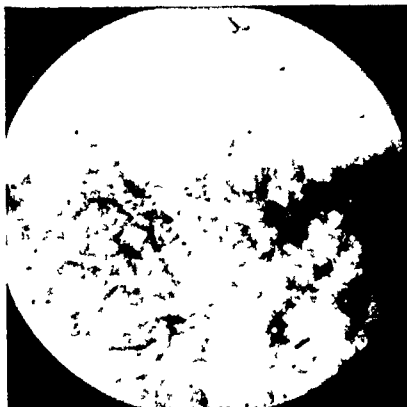


FIG. 4.

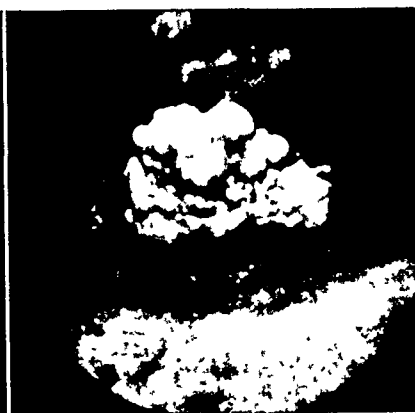


FIG. 5.



FIG. 6.



FIG. 3. Cystitis of moderate intensity. Note the dilated veins and the marked congestion of the mucosa.

FIG. 4. Solitary vesical calculus, lying upon the highly inflamed mucosa. The mucosa is so inflamed as to appear as a dark shadow. In the foreground is the interureteric ridge.

FIG. 5. Diverticular opening of the bladder. Note the striations of the mucosa radiating toward the opening.

FIG. 6. Carcinoma of the bladder. Note its irregular shape. The blood vessels on the floor of the bladder are somewhat enlarged and there is evidence of cystitis to the sides and posteriorly to the tumor mass.

most accurate description of such changes, however, is definitely inadequate. It is impossible to have a trained artist at one's command at all times. Once treatment has begun, even though a trained artist is available, it is impossible to portray graphically the changes and alterations that many of these lesions assume. Regardless of the accuracy of the artist, the lesion depicted by him is as he observes it and often not as observed originally by the cystoscopist, this error being due to some uncontrollable motion of the patient or the cystoscope which would, of necessity, give

lesion cystoscopically, in its different stages of advancement or regression, would be of material aid in the institution or alteration of any definite and prescribed treatment. Again, in the teaching of students, be they graduates or undergraduates, to be able by means of a photograph to impress clearly upon the minds of the students the appearance of a pathological lesion or anatomical landmark will aid materially in their personal visualization. To the undergraduate student or the beginner in cystoscopy, it is usual that they are entirely lost and grope aimlessly about the

vesical cavity, trying to find a landmark, due to the fact that their perspective is entirely lost. So that in comparison, if a photograph may be shown in conjunction with a line drawing as to the position of the anatomical landmark or a pathological lesion, a definite mental picture is established in the mind of the student.

We have established a permanent exhibit of photographic transparencies at Temple University Medical School, which contains many of the normal landmarks as well as many pathological lesions of the bladder. These transparencies are used routinely in teaching the students at the time of cystoscopy. It is not our purpose to make cystoscopists of every individual, but rather to establish a definite correlation, ideas or impressions, of the normal bladder mucosa and normal vesical landmarks as well as some of the more frequently observed vesical lesions. We believe that photography, in conjunction with visualization of the normal bladder, is a sound method of establishing a permanent impression of normal vesical anatomy, which impression will be carried away by the student after he leaves medical school.

#### CONCLUSIONS

A photographic record of any vesical lesion is incalculable, either in recording the advancement or regression of such a lesion under treatment.

Cystoscopic photographs are basically sound in teaching students, because the student's perspective is not lost as it is upon observation through the cystoscope.

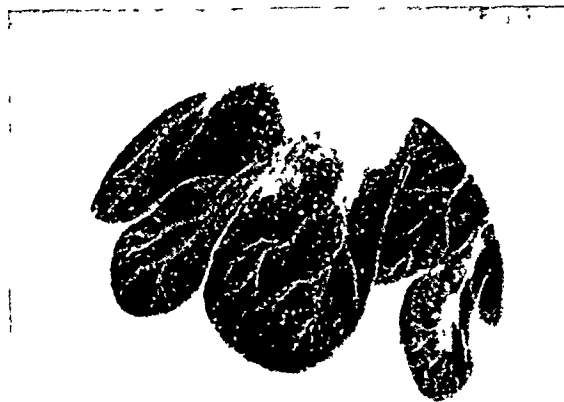


FIG. 7. Polypoid formations on the vesical neck in the female. There is a definite vascularity with a marked congestion at the base of the largest polyp. On occasion, these polyps account for a considerable and unexplained hematuria.

A cystoscopic camera, in the armamentarium of every urologist, would aid materially in accurate depiction of pathological lesions for our textbooks or scientific articles and would make possible a definite and permanent record of the changes or alterations of any given lesion under treatment.



# THE COLLOIDAL METALLIC SILVER TAMPON FOR TREATMENT OF RHINITIS, SINUSITIS, ETC.

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CILIARY action, mucous secretion, phagocytosis—these are the three most valuable assistants the physician has in the treatment of almost any infection of the respiratory mechanism, and any method of treatment of rhinitis, sinusitis or other nasopharyngeal affections must be designed to support these powerful factors.

The aim of therapy must be restoration of normal function—*normal mucous secretion*, to maintain an even temperature of underlying tissues and to collect and remove dust particles and other foreign substances entering the nostrils—*normal ciliary action* to help in the evacuation, anteriorly and posteriorly, of normal and abnormal secretions—*normal phagocytosis* to restore the natural defense of the tissues against bacterial invasion.

When these natural defenses succumb temporarily to bacterial invasion, the ear, nose and throat man must assist them with drugs and certain mechanical procedures which have been developed to relieve congestion and permit removal of those irritating factors which are delaying or interfering with normal tissue operation.

The choice of drugs is important. Experience seems to indicate that what is needed is a drug which has antiseptic, tissue-stimulant and cleansing properties, but, unfortunately, drugs with strong antiseptic and bactericidal properties cannot be employed since these, by their destructive action on the tissues themselves, throw an additional burden on the natural defenses instead of aiding them.

Silver, in one or other of its various forms, seems to be almost the only drug available at the moment which most nearly meets the requirements of the case, and for

this reason it is the choice of the large majority of otorhinolaryngologists. Voorhees' study (*Eye, Ear, Nose and Throat Monthly*, August, 1934) showed that out of 2,924 eye, ear, nose and throat men replying to the question, "Do you use the silver salts?", 86 per cent stated that they used them in preference to nonsilver agents.

There is every reason to believe that silver still retains a similar prominence in the eye, ear, nose and throat armamentarium. Silver nitrate, a soluble *salt* of silver is naturally quite limited in its application, because of its pronounced caustic, astringent and highly irritating properties, but the colloid type of silver product is almost unlimited in its application.

All such products are foreign to the body and all have low antiseptic values when determined by governmental standards for antiseptics, but they exert their antiseptic action upon micro-organisms found in the nose by continuous action on contact, which results in the liberation of a low but effective concentration of silver ions. This constant antiseptic action is accomplished only by means of tampons which can be left in contact with the chronically congested nasal membrane for as long a period of time as the doctor's individual experience may indicate to be necessary.

In the Proetz technic of application of medication to the sinuses by means of displacement, silver in its various forms is used and is to be commended in those cases in which a simple application of medication is required. This method cannot be employed successfully in all cases.

Sprays are inefficient in that they do not keep tissues in contact with the medication long enough for any special action to take place and merely serve as lubricants. Hypo-

dermic injections into the nasal tissues have not been employed by the author for the treatment of chronically congestive rhinitis.

The main action of the nasal tampon is that of keeping tissues in contact with the drug for a period of time. The mechanical action of the tampon stimulates the columnar epithelium and goblet cells to an increased secretion of mucus, thereby cleansing themselves. This necessitates an increased capillary flow as well as vasomotor activity. The second action is the absorption of the drug employed.

Bearing in mind that contact under pressure is preferable to other procedures in applying the drug, care must be taken in choosing the drug to use upon the nasal tampon. It must be nonirritating and leave no bad after effects.

I always use colsargen, which is a colloidal suspension of metallic silver. This penetrates the mucous membrane by osmosis and acts as an alterative, the latter action occurring as nature endeavors to rid itself of any foreign body, no matter how minute, and in so doing calls for an increased blood supply with phagocytic action. A stimulation of the cells to an increased mucus production also takes place.

Dowling's method of using a well-wrapped, cotton-tipped applicator with argyrol and other silver protein salts, presents too small a surface for any absorption effects, but owing to the pressure exerted by a large tightly wrapped applicator tampon, mechanical stimulation is the only action attained. In the Dowling method, common salt, bicarbonate of soda or any medication would give the same result.

For office use the author prefers a flat tampon of uniform thickness, moistened with colsargen, undiluted, and the excess squeezed out. This tampon is about two inches long and about three-eighth inch wide and something less than one-eighth inch thick. If it is desirable to leave the tampon in place longer than fifteen or twenty minutes, a piece of white or flesh-colored, heavy silk thread is tightly at-

tached to one end of each tampon and tied under the columna. All dangling threads are cut. This is barely noticeable to others and the tampons may be removed by the patient himself at a specified time.

Preparation of a patient prior to the introduction of a tampon is most important. The nasal chambers are sprayed with a 1½ or 2 per cent solution of cocaine hydrochloride and after waiting a few minutes a postnasal cleansing, consisting of a group of alkaline solutions (to dissolve the mucus and separate it from the mucosa) is employed. After this the tampon is prepared. It has been the author's experience to leave the tampons *in situ* for at least fifteen minutes with the use of external heat by means of an infra-red lamp. This seems to stimulate the vasomotor system and cuts the time of treatment in half. During the summer months or if the patient can spare the time, the tampon is left in place for thirty minutes without heat. There is no irritation whatsoever in the use of colsargen. It appears to have the same action at all times. The progress of treatment can be ascertained by inspecting the tampon after its removal and comparing it with the color of the tampon as it was introduced. One will find the color gradually diminishing as the tissues return to normalcy. Naturally, when the tampon is introduced between two tightly covered surfaces the drug would be squeezed out and the tampon appear perfectly white after its removal. This must be taken into consideration in using colsargen as a means of diagnosis.

The author has used colsargen for the past nine years and a study of the records of its use in the treatment of 140 cases of acute and chronic congestive rhinitis and sinusitis, shows that its greatest efficiency has been found in these conditions. When there is a nasal obstruction, this is best corrected before using nasal tampons, but in the event of the refusal of the patient to consent to operation, the colsargen will help in reducing the nasal swelling. This applies also to hypertrophic rhinitis with-

out polypi or polypoid degeneration of the mucous membrane.

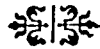
The author has introduced colsargen directly into the antra and sphenoidal cavities through a cannula (intra ostia). The affects of this method of treatment of sinusitis have been good but not as marked as when used on tampons. Of course, the sinuses must first be irrigated to remove all mucus.

The advantages in the use of colsargen to other silver solutions are in its uniformity and its readiness for use. It is isotonic and

therefore readily absorbable and nonirritating. It does not diminish or destroy ciliary action. Its stain is readily removable with water.

#### SUMMARY

An effective convenient tampon, prepared with a nonirritating isotonic colloid of metallic silver for the treatment of certain nasal infections has been developed by the author and results of its use in 140 cases of acute and chronic, congestive rhinitis and sinusitis are reviewed.



THE true hemangioma in the oral cavity is most often a fluctuant growth, in contradistinction to the vascular granuloma, which is rather compact.

From—"Pathology of the Oral Cavity"—by Lester Richard Cahn (Williams & Wilkins Company).

# METHYL CELLULOSE SOLUTION AS A PLASMA SUBSTITUTE

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THE limited availability and the difficult preparation and handling of blood plasma for the treatment of shock represent an urgent indication for continued research on nontoxic, macromolecular substances capable of re-establishing and maintaining over prolonged periods an adequate total blood volume, a normal cell-plasma ratio and a normal blood viscosity. The colloidal solutions of several nonhematogenous, macromolecular substances, such as gum acacia (Bayliss, 1918), polyvinyl alcohol (Stierlen, 1939; Jorns, 1940), gelatin (Taylor and Waters, 1941) and pectin (Hartman, Schelling, Harkins and Brush, 1941), have been recommended for this purpose. However, none of these substitutes is entirely satisfactory for various reasons, such as difficult sterilization, defective stability, variable purity and chemical composition, antigenicity, toxicity and production of storage phenomena with their associated functional organic disturbances (Hueper; Hueper, Landsberg and Eskridge; Martin and Hueper). If methyl cellulose is presented in the following report as a new plasma substitute, it is done for the purpose of calling attention to a megalomolecular compound which possesses a combination of desirable physicochemical properties lacking in the above mentioned agents.

## EXPERIMENTAL PART

Methyl cellulose, which is the methyl ether of cellulose and consists of a long chain of dextrose molecules, is manufactured industrially as a mucilage used extensively for various purposes. It is a white, light, fluffy material which comes in seven grades of viscosity (15, 25, 50, 100, 400, 1,200 and 4,000 centipoise units for a

2 per cent aqueous solution). It is readily soluble in cold water giving a water-clear, viscous, colloidal solution which has a neutral reaction and which gels when heated, finally coagulating into a milky coagulum at higher temperatures (above 65°C.). This heat coagulation of methyl cellulose, which resembles that of blood serum, is reversible, however, on cooling. Solutions of methyl cellulose can, therefore, be sterilized by autoclaving under pressure without losing their physicochemical properties, such as seen with solutions of gum acacia and pectin, which under such conditions develop precipitates and show a marked decrease in viscosity. Methyl cellulose solution is also refractory to infection with the ordinary bacteria, as it does not sustain the growth of these microorganisms. Methyl cellulose is precipitated out of its aqueous solution by the addition of various salts, such as ammonium sulfate, and behaves in this respect similar to the euglobulins of the blood plasma.

The methyl cellulose used in the experimental work is of the highly viscous type, having a molecular weight of well above 50,000. A 0.25 per cent solution of this substance at 20°C. is twice as viscous as water and thus displays a viscosity equal to that of normal human and canine plasma. A colloidal solution of methyl cellulose injected intravenously forms with the plasma proteins a relatively stable emulsion, which can be broken by prolonged centrifugation at high speed.

Before the suitability of methyl cellulose solution as a plasma substitute was studied experimentally, a number of toxicopathological investigations were undertaken to determine the acute and chronic effects of intravenously introduced methyl cellulose

solution upon the blood and the organs of dogs and rabbits. As the results of these experiments will be published in detail elsewhere, they may be briefly summarized here:

The intravenous injection of 10 to 30 cc. of a 5 per cent methyl cellulose solution in normal saline is followed by a marked transitory leukopenia, a prolongation of the coagulation time and an increase in the sedimentation rate, i.e., manifestations of a colloidoclastic crisis, such as is observed after the introduction of foreign colloidal material of various nature and especially of foreign proteins, gelatins, gum acacia, polyvinyl alcohol and pectin. A repeated and prolonged intravenous administration of a 2 per cent methyl cellulose solution is followed by a gradual reduction in the number of erythrocytes and in the amount of hemoglobin, by an increased plasma viscosity, a persistent myeloid leucocytosis, an accelerated conglutination and sedimentation speed of the erythrocytes and a delayed clotting of the blood. The examination of the internal organs of animals thus treated reveals the storage of methyl cellulose in the liver cells, splenic reticulum, kidney and the endothelium of arteries, producing thereby the symptoms of a thesaurosis similar to that seen under corresponding circumstances in animals injected with gum acacia, polyvinyl alcohol, pectin, cholesterol, etc. None of the rabbits and dogs used in these experiments showed at any time any acute symptomatic toxic reaction following the intravenous introduction of the methyl cellulose solution, because this substance is chemically relatively inert and very stable. None of the dogs which received these excessive doses of methyl cellulose and of which some were reinjected with methyl cellulose solution after the course of treatment had been interrupted for four weeks showed any signs of hypersensitivity. Methyl cellulose does not possess, therefore, any antigenic properties. The colloidal osmotic pressure exerted by a 1 per cent methyl cellulose solution is approximately 6 cm. of water

and is thus in the neighborhood of that shown by a 1 per cent albumin solution.

After having thus demonstrated the type and extent of the physiological and pathological reactions in the blood and tissues elicited by the introduction of methyl cellulose solution given in moderate as well as excessive amounts and concentrations and after having thus determined the therapeutic limitations of this kind of medication, the efficacy of methyl cellulose solutions in the treatment of shock was investigated. The methyl cellulose solution used in the shock experiments was prepared by dissolving 2 Gm. of methyl cellulose in 100 cc. of physiological saline. This stock solution was diluted to 1 per cent, 0.5 per cent and 0.25 per cent by the addition of a solution of several substances exerting a detoxicating influence upon endogenous or exogenous toxic agents, such as histamine, indol, skatol, aromatic compounds, lead and certain arsenicals. This detoxicant solution contained 2 Gm. of ascorbic acid, 1 Gm. of calcium glucuronate, 1 Gm. of glycine and 0.5 Gm. of cysteine hydrochloride. This solution, which is moderately hypertonic, was always freshly prepared, as it disintegrates within the course of several hours to a noticeable degree following its neutralization by the addition of  $n/10$  sodium hydroxide. The effectiveness of these detoxicants against histamine and other toxic biogenic amines was demonstrated in separate experiments (Martin, Rennebaum and Thompson).

This combination of a colloidal solution of a macromolecular substance with detoxicating agents was chosen for the following reasons: The most important symptom of the syndrome of shock is the hemoconcentration caused by an abnormal vascular and particularly, capillary permeability, permitting the escape of water, crystalloids, colloids, and finally also of cellular elements from the blood, producing thereby a collapse of the circulation and an anoxemia of the tissues. The first and basic requirement of any shock therapy is, therefore, the restoration of the disturbed water balance

of the blood. The water balance of the plasma and thus the total blood volume is normally controlled by the following factors: (1) the colloidal osmotic pressure of the macromolecular colloids, i.e., the various proteins, contained in the plasma; the size of this pressure depends upon the amount and the ratio of the various proteins; the relatively small molecular albumins are responsible for the major portion of it, while the larger molecular globulins and especially fibrinogen account for only a minor portion of it; (2) the water retaining power of these hydrophilic colloids; (3) the osmotic pressure exerted by the numerous crystalloids; (4) the permeability of the vascular wall; and (5) the filtration pressure of the blood, which in turn depends upon the blood pressure.

The immediate aim of any shock therapy must be twofold: (a) a restoration of an adequate total blood volume by the introduction of sufficient quantities of a colloidal solution of a hydrophilic macromolecular substance whose molecule is so large that it does not readily pass through the excessively permeable vascular wall and which through its water retaining properties is capable of maintaining the blood volume over a prolonged period, until the natural restorative powers of the organism can come into play. It is obvious that under such circumstances the colloidal osmotic pressure of the macromolecular agent can play at best only a minor rôle in this respect because of the especially large molecular size of the colloid required; (b) a re-establishment of a normal vascular permeability by the use of agents which counteract the causative vasculotoxic factors active in shock.

These considerations lead to the adoption of a combination of a solution of a macromolecular colloid with certain detoxicating substances as a therapeutic agent in experimental shock.

Shock was produced in dogs either by the application of dry ice to the skin of the back or by the repeated subcutaneous injection of a histamine solution suspended

in oil. The methyl cellulose-detoxicant solution was usually administered repeatedly in individual doses of 120 to 130 cc. In general, equal parts of the two component solutions were combined in the mixture given. The intensity and the course of the shock as well as the effects of the treatment were estimated from the following data obtained in frequent intervals: hemoglobin, number of erythrocytes, volume of packed red blood cells, number of leucocytes, differential count and coagulation time. These criteria were used in preference to blood pressure determinations, as the comprehensive investigations of Moon have shown that the blood changes represent the more reliable evidence in judging the onset and the severity of a shock and that they precede the lowering of the blood pressure observed in shock. Repeated blood pressure determinations necessitate, moreover, the use of bloody methods and of anesthesia, both factors which may introduce serious experimental errors.

*1. Shock by Freezing.* After the removal of the hairs from both sides of the back with an electric shaver over an area measuring approximately 12 by 15 cm. on each side the dogs were lightly anesthetized with ether and strapped down upon two oblong bags filled with crushed dry ice and moistened with water to obtain an intimate contact with the skin. At the end of the treatment, which lasted for thirty to forty minutes, the skin and the underlying tissues of the exposed regions were frozen hard to board-like consistency. With subsequent thawing they became first highly red and blotchily hemorrhagic and several hours later showed a bluish purple color and a highly edematous, baggy appearance. This reaction receded in general within the first twenty-four hours and was followed by a diffuse necrotic sloughing of the skin, leaving a large, granulating, ulcerative defect in those dogs which survived for more than a week. There were twenty-one dogs in the experiment, of which eight served as controls receiving no antishock therapy. All dogs which survived the immediate effects



of the shock or which did not die subsequently from secondary complications, such as pneumonia and septicemia, were killed at the end of a fourteen days' period. Table 1 presents the hematological findings observed in four representative members of both the experimental and control groups of this series of dogs. (Table 1.)

dogs died within the first seventy-two hours, while only one out of the thirteen treated dogs died during this period of acute shock action.

*II. Shock by Histamine Injection.* In view of the fact that it was found difficult to produce a progressive and satisfactorily standardized type of fatal shock by freez-

TABLE I

Dog	Before			2-4 Hours			5-7 Hours			8-10 Hours			24 Hours			48 Hours		
	E	V P E	L	E	V P E	L	E	V P E	L	E	V P E	L	E	V P E	L	E	V P E	L
Experimental																		
518	4 81	43 0	10 7	7 39	60 5	21 0	7 40*	59 5	31 0	6 11*	51 0	15 2	5 61	46 0	28 1	6 73	45 0	29 8
527	6 56	49 6	13 8	6 65	56 0	28 8	7 16	60 0	22 28	28*	63 0	33 3	6 46*	49 0	35 0	6 40	42 0	25 2
529	7 31	50 0	11 0	9 50	69 5	21 6	10 3*	71 0	24 8	24*	65 0	9 1	6 95	54 5	18 8	6 52	49 5	27 9
541	7 37	57 5	16 5	8 82	62 0	37 9	9 07*	63 5	38 0	8 31	62.0	37 9	6 77	52 0	24 31	5 68	45 5	25 0
Control																		
517	8 02	59 7	14 4	9 91	78 5	23 6	9 6*	75 0	30 5	8 33	73 0	31 7	8 99	68 0	26 9	9 54	72 5	33 8
522	7 94	56 3	24 2	8 43	66 5	23 0	8 29	59 5	26 0	7 12	62 0	26 8	8 54	71 0	26 0	7 18	56 0	24 2
524	7 30	47 0	12 5	8 21	58 0	20 8	7 64	56 0	20 4	7 24	55 0	26 4	7 57	57 0	16 6	6 91	50 0	24 2
539	7 50	53 7	17 7	8 47	61 0	18 1	7 42	60 5	22 2	7 04	59 0	25 2	8 01	60 0	21 8	7 55	49 0	31 1

\* Injection of methylcellulose solution after this count

E Erythrocytes

V P E Volume of packed erythrocytes

L Leucocytes

An analysis of the data recorded in Table 1 shows that the freezing of large areas of the skin causes a moderate to considerable but transitory erythrocytosis and leucocytosis, as well as a temporary increase in the volume of packed blood cells, usually lasting twenty-four hours, after which time normal or sometimes even slightly subnormal values are again attained in the control dogs. On the other hand, if at the height of these reactions, i.e., five to ten hours after the freezing, methyl cellulose solution is administered, there occurs a sudden drop in the pathological increases in the number of erythrocytes and the packed blood cell volume leading rapidly to values which are considerably below the original ones and which persist for at least forty-eight hours. The time of hemoconcentration is thus cut short and a prolonged hemodilution is produced. This apparent beneficial effect exerted by the treatment given upon the hemoconcentration is reflected also by the survival rates of the two groups, as five of the eight control

ing, the experimental investigations were extended to shock caused by the action of subcutaneously administered histamine. Inasmuch as it appeared desirable to imitate as closely as possible the conditions present in traumatic shock in man, histamine base or hydrochloride was injected in refracted doses given at intervals of one to three hours and incorporated in an emulsion of peanut oil and lanolin, in order to slow up its absorption. From two to five injections were made. The individual dose ranged from 0.03 Gm. to 0.003 Gm. of histamine per kg. of body weight, while the total dose varied between 0.03 Gm. and 0.0075 Gm. per kg. of body weight.

The symptoms of shock, such as vomiting, diarrhea (often hemorrhagic), rapid labored respiration, rapid pulse, foaming at the mouth, greatly increased thirst, and prostration, developed gradually under this management within three hours after the start of the treatment. The therapeutic measures were instituted when either the blood changes or severe symptomatic mani-

TABLE II

Dog	I Histamine Dose, Gm.	Before			2-4 Hours			5-7 Hours			8-10 Hours			24 Hours			48 Hours		
		E.	V.P.E.	L.	E.	V.P.E.	L.	E.	V.P.E.	L.	E.	V.P.E.	L.	E.	V.P.E.	L.	E.	V.P.E.	L.
Experimental																			
602	0.06	6 64°	52 0	27 1°	7 35°	59 0	20 1°	7 68*	55 0	31 0*	6 52*	49 5	25 6*	6 23	48 0	22 8	5 33	41 5	28 3
583	0.06	7 84°	54 5	13 2°	9 32°	59 0	26 7°	9 05*	75 0	28 6*	7 43*	53 5	16 4*	6 63	52 0	21 9	6 64	51 5	13 2
622	0.075	6 78°	54 5	15 4°	8 03°	59 0	26 7°	8 24*	59 0	29 2*	7 81*	53 0	4 2*	6 46	39 0	10 8	6 66	45 0	10 9
639	0.092	6 95°	47 5	18 0°	8 50*	55 0	27 2°	8 03*	50 0	27 9*	6 95*	45 0	27 9*	5 90	35 0	13 6	5 81	39 0	22 0
591	0.095	6 18°	47 5	5 1°	6 94°	49 0	11 1°	7 12°	55 0	17 2°	*6 35*	48 0	18 9*	6 05	46 0	15 6	4 96	40 5	13 8
575	0.07	7 62°	50 0	14 3°	8 35°	60 5	22 9°	8 57*	56 5	26 1*	6 25*	49 0	24 9*	5 63	41 0	18 0	6 17	42 3	12 7
665	0.195	5 19°	37 0	24 3°	5 85°	37 5	39 2°	6 02*	39 0	55 2	4 84*	38 0	52 1*	5 17	36 0	34 7	†	†	†
612	0.09	5 92°	51 5	10 8°	7 07°	49 0	16 0°	7 39°	49 5	20 8°	6 67*	49 0	12 7*	7 29	43 5	13 2	6 83	45 0	22 4
	0.10	5 11°	42 0	9 8°	6 38	45 0	16 6	6 4*	42 0	14 5*	5 57*	38 0	26 8	5 87	37 0	15 6	6 09	37 3	9 9
631	0.12	6 60°	54 0	10 1°	9 06	58 0	17 9°	6 74°	48 5	18 2°	6 01*	39 0	15 2*	6 15	44 0	9 9	†	†	†
	0.15	5 67°	41 5	7 8°	6 05°	42 0	7 4°	6 18°	42 0	7 0°	*4 86*	38 0	*8 8*	4 46	37 0	8 8	†	†	†
Controls																			
617	0.18	7 16°	60 6	6 05°	8 02°	66 0	11 4°	8 27	66 5	30 4	9 25	72 5	30 2	†	†	†	†	†	†
574	0.08	7 98°	54 0	13 4°	8 00°	54 0	16 0°	8 82	57 5	24 8	8 44	51 0	34 4	†	†	†	†	†	†
586	0.052	7 57°	56 0	13 6°	8 61°	59 0	17 6°	8 35	73 0	21 7	9 50	75 0	27 6	†	†	†	†	†	†
603	0.175	6 01°	47 5	9 6°	7 16°	54 0	13 0°	6 70	53 0	17 4	7 22	54 0	21 3	7 30	51 5	19 9	5 65	41.0	10 4

\* Injection of methyl cellulose solution.

† Death.

E. Erythrocytes.

V.P.E. Volume of packed erythrocytes.

L. Leucocytes.

° Injection of histamine.

festations indicated the existence of a severe and progressive shock. A total of forty-two dogs was used in this experiment. Seven of these dogs received only histamine and served as controls.

Table 11 presents the observations made in four control dogs and ten experimental dogs treated with methyl cellulose-detoxicant solution. They were selected from the total number as representative examples. (Table 11.)

The data recorded in Table 11 show that the repeated injection of methyl cellulose-detoxicant solution in adequate quantities and suitable intervals exerts a decidedly favorable effect upon the hemoconcentration, the hyperleucocytosis and the volume of the packed erythrocytes elicited by the subcutaneous injection of histamine. The considerable and prolonged hemodilution following upon this type of therapy is a striking feature. Its life saving character appears to be evident from the fact that two dogs which had developed a leucocytosis of 55,000 and 61,000 cells and thus, according to Moon, were well within the fatal range of shock leucocytosis, survived.

#### COMMENT

Observations made in dogs subjected to shock by freezing or by the subcutaneous injection of histamine indicate that the repeated intravenous administration of a moderately hypertonic solution of methyl cellulose fortified by the addition of several detoxicating substances (ascorbic acid, calcium gluconate, cysteine hydrochloride and glycine) causes a rapid reduction of the hemoconcentration and leucocytosis followed by a stabilization of the number of erythrocytes and of the volume of the packed red blood cells at or below the initial level for periods extending for more than forty-eight hours. Simultaneous with this improvement of the blood changes associated with shock, there occurs a corresponding beneficial effect upon the action of the heart, evidenced by the appearance of a slowed, strong pulse, and upon the general vitality. The injection of a 0.5 to 1

per cent solution of methyl cellulose into the jugular vein does not elicit any acute untoward reactions even when administered at great speed. Mention may be made, however, of the fact that the intravenous injection of an excessively viscous solution of methyl cellulose (4 to 5 per cent) is inadvisable, as such a medication causes a sudden and marked temporary increase in the viscosity of the blood which accentuates the circulatory embarrassment already existing in shock.

It may be noted also that attempts made to follow the changes in total plasma volume by the photo-electrical colorimetric determination of the injected dye (T 1824) failed, as highly erratic results were obtained. Thus, similar observations made with this method in shocked animals by Magladery, Solandt and Best could be confirmed. The abnormal permeability of the capillaries present in shock interferes evidently with the proper retention of the dye in the blood.

The main objection which may be raised against the use of methyl cellulose for the purpose discussed is represented by its retention in various organs, especially the liver, spleen and kidney. However, it shares this quality with several of the other agents (gum acacia, pectin, polyvinyl alcohol) proposed as blood substitutes, which also are stored in these organs and interfere thereby with their normal functional activity, particularly the regeneration of plasma proteins by the liver. Although this drawback bars methyl cellulose solution from any future therapeutic use in the control of hypoproteinemia, it does not militate against its employment as a plasma substitute in the emergency treatment of shock, when plasma may not be available. The existence of several types of methyl cellulose differing in molecular weight offers, moreover, the opportunity to choose from a series of macromolecular agents, with gradated colloidal and physico-chemical properties as to colloidal osmotic pressure and vascular permeability, that particular compound which is least hazard-

ous and most suitable and efficacious as a nonhematogenous plasma substitute.

The advantages which methyl cellulose possesses may be summarized as follows:

1. Methyl cellulose is a substance readily available from industrial sources in this country and does not need to be imported, such as gum acacia.
2. Methyl cellulose is obtainable as a relatively pure substance readily soluble in water giving a water-clear, neutral, stable solution, which is not changed in its physicochemical properties by heating, such as occurs with solutions of gum acacia, pectin and gelatin.
3. Methyl cellulose solution is refractory to bacterial infections and can, therefore, be handled under emergency conditions with greater safety than solutions of gum acacia, pectin and gelatin.
4. The chemical uniformity, purity and stability of methyl cellulose guarantees the production of a solution of standardizable qualities and contrasts with the chemical variability of gum acacia and pectin and their frequent contamination with toxic exogenous substances.
5. Methyl cellulose is nonantigenic and does not elicit, therefore, any hypersensitive reactions, such as produced by gum acacia and fish gelatin.

#### CONCLUSIONS

Dogs subjected to shock produced by freezing or by the subcutaneous injection of histamine show a rapid reduction in hemoconcentration and a subsequent prolonged moderate hemodilution following upon the intravenous injection of a 0.5 to 1 per cent solution of methyl cellulose fortified by the addition of several detoxicating chemicals (ascorbic acid, cysteine hydrochloride, calcium gluconate, glycine).

The relatively rapid administration of such a solution is invariably tolerated without any acute untoward reactions.

The potential therapeutic use of this agent in man is subject to the same limitations as those applying to other macro-

molecular colloidal agents which are used as plasma substitutes (gum arabic, polyvinyl alcohol, pectin) and which produce upon long repeated introduction of excessive amounts hazardous storage phenomena.

Methyl cellulose and its aqueous solution possess a number of physicochemical qualities which make them superior to other nonhematogenous macromolecular blood substitutes for the restoration and maintenance of the blood volume reduced under the conditions of shock.

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# TREATMENT OF FEMALE MENOPAUSE WITH METHYL TESTOSTERONE AND STILBESTROL\*

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THE use of male sex hormone in female menopause has been reported by various observers. Kurzrok, Birnberg, and Livingston described a large series of women successfully treated for the complaints of menopause by administration of 40 to 50 mg. of testosterone propionate weekly by injection. Efforts have repeatedly been made to prevent recurrence of bleeding in women at the menopause, particularly in those women who had undergone x-ray or radium therapy for functional menorrhagia or metrorrhagia. It has been frequently demonstrated that the continued treatment of female menopause with estrogenic hormones will produce irregular uterine bleeding. In an effort, therefore, to prevent this undesirable consequence, we have used a combination form of treatment, using methyl testosterone and stilbestrol orally. Detailed description of properties and actions of stilbestrol are unnecessary at this time, as they have been clearly elucidated in a previous publication by Kurzrok, Birnberg and Weber, as well as other investigators.

Methyl testosterone, 17-methyl $\Delta^4$ androst-17 (trans)-one-3, is a synthetic, crystalline, chemically pure compound, practically insoluble in water, but soluble in alcohol, ether, and other organic solvents, and melts at 165°C. It differs chemically from testosterone propionate, and its metabolism is probably not identical, the additional group acting to prevent its destruction or modify its absorption in the gastrointestinal tract. Examples of its different action are: (1) ability to restore the depressed metabolic rate in eunuchoids, and (2) a greater degree of body fluid and salt retention.

Shapiro found that methyl testosterone induced ovulation in *Xenopus laevis*, the South African clawed frog.

Duffy and Corsaro determined that methyl testosterone administered by mouth, in doses of 25 mg. at intervals of four hours for six doses, produced inhibition of lactation postpartum comparable to that obtained with 50 to 75 mg. of testosterone propionate administered subcutaneously.

Selye demonstrated that various steroid hormones, especially desoxycorticosterone acetate and progesterone produce deep anesthesia in rats and mice if injected into the peritoneum whence they can be rapidly absorbed. Methyl testosterone, in doses of 50 mg. administered in this way, produced deep anesthesia in 50 per cent of the animals used.

Goldzieher mentions the use of methyl testosterone in menorrhagia, in doses of 25 mg. twice daily orally, but does not state results.

McCullagh found that oral methyl testosterone is effective therapy in eunuchoidism. In terms of clinical symptoms its effectiveness as compared to testosterone propionate injections approximates 3 or 4 to 1. The metabolism of methyl testosterone differs from that of testosterone propionate in that clinically effective doses of the propionate are followed by a rather marked increase in urinary androgens. With methyl testosterone, this sequence does not occur to the same extent. Methyl testosterone has the power to raise the basal metabolic rate. A dosage of 25 to 75 mg. per day was employed and well tolerated. Gain in weight in some cases has been a prompt and rather striking feature. On doses of 75 mg. a day, weight gains on the

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order of ten pounds in two weeks have been seen. One man voluntarily discontinued taking the drug because of an uncomfortable sense of bloating, associated with a gain of thirteen pounds in weight in twenty-three days. In another case, a similar gain in weight was associated with severe headache. This patient had undergone the removal of a pituitary tumor the month before, and it was suspected that the headache was caused by an increase in intracranial edema. Such increases in body weight suggest that the effect of methyl testosterone on sodium, chloride and water retention is similar to that seen following the use of testosterone propionate and other related steroids.

Tager and Shelton, and Kearns found that methyl testosterone is practical and efficacious in oral administration. In patients with marked testicular deficiency, who were previously treated with testosterone by various routes, it duplicated and maintained all of the beneficial effects. The ill effects are negligible, slight gastric irritation being the only unpleasant by-effect observed. Approximately four to six times the inunction and injection dosage is required.

Miescher and Tschopp have demonstrated that methyl testosterone is considerably more active by mouth than testosterone, androstanediol, androstenedione, testosterone propionate, and androsterone in castrated male rats as shown by the increase in weight of the seminal vesicles and prostate. They suggested that possibly greater protection of the active hydroxyl group from fermentative influences in the alimentary canal was acquired from the adjacent methyl group. Foss reported three cases of eunuchoidism and hypogonadism treated by methyl testosterone administration with excellent results. One patient complained of some symptoms of slight nausea, anorexia and dyspepsia, which were relieved by a little alkaline mixture. The effect of methyl testosterone was twice that of a similar amount of testosterone by mouth.

Biskind et al. treated seven typical cases of eunuchoidism, by implanting pellets of crystalline methyl testosterone and in 1 case crystalline testosterone propionate. Total dosage was between 83 and 180 mg. compressed into pellets averaging 5 to 6 mg. each. The duration of effectiveness averaged seven to eight weeks. Testosterone propionate pellets seemed somewhat more potent clinically, but methyl testosterone was easier to prepare and safer to administer. The absorption from each pellet of methyl testosterone was approximately 0.10 to 0.17 mg. per day. The high melting point of methyl testosterone pellets permits sterilization in the pressure autoclave, thus materially reducing the possibility of contamination. The experience indicates that the uniform continuous absorption from such pellets is more efficient than injections of the hormone in oil so that about one-fifth of the dosage is required to obtain similar results. The eventual cost of continuous treatment should be less, therefore, and the interval of about seven weeks between implantations is a decided improvement over injections two to seven times weekly.

We have treated sixteen cases of female menopause, both spontaneous and surgically produced, by the administration of methyl testosterone and stilbestrol orally. Three women suffered from arthralgia, and three from pruritus vulvae, in addition to the flushes, headaches and sweats of female menopause.

Dosage varied from 5 to 25 mg. of methyl testosterone daily, usually 25 mg. being administered, and 2 to 3 mg. of stilbestrol daily. The duration of treatment was between one and six months. Total dosage ranged between 750 to 3565 mg. of methyl testosterone and 60 to 450 mg. of stilbestrol.

Improvement or complete relief from symptoms of menopause was obtained in all cases. Two cases of pruritus vulvae were benefited and one was unimproved. The three cases of arthralgia were improved in varying degrees.

Vaginal smears and acidity determinations were done at intervals of one to two weeks. The vaginal smear demonstrated an original reduction of epithelial reaction of the mucosa, with a secondary improvement, after several weeks. However, there were very few plus 4 vaginal smear readings. There was no corresponding change in vaginal acidity noted. The vaginal hydrogen ion concentration in some cases was reduced, in others increased. No correlation between vaginal hydrogen ion concentration and vaginal smear was apparent during therapy in this series.

Absence of uterine bleeding, or its extent and amount when present were carefully studied. Five cases of spontaneous menopause continued to menstruate with fair regularity with no apparent change in duration or amount. Two cases of spontaneous menopause who had bled considerably while receiving estrogenic substitution therapy, had only moderate bleeding during combined therapy. Three women with spontaneous menopause with an amenorrhea of from five to thirty-six months had no bleeding during treatment. Five patients who had undergone hysterectomy and bilateral oophorectomy had no vaginal bleeding. One patient in whom a bilateral oophorectomy had been performed two years previously suffered no bleeding during the course of medication.

There was little variation in weight recordings, the greatest change being a loss of eight pounds over a period of four months in one patient.

In one woman there was a lowering of voice for several weeks following the administration of 1,565 mg. of methyl testosterone and 142 mg. of stilbestrol over a period of six months. This disappeared after withdrawal of medication. There were no other evidences of masculinization such as hirsutism, enlargement of the clitoris or changes in the breasts, in our series.

Reactions were noted as follows: four patients suffered from anorexia or nausea; one patient had severe nausea with vomiting after one week of treatment necessitat-

ing discontinuation of therapy; one patient had a generalized papular eruption with pruritus after seven weeks of treatment. The total dosage given was 1,250 mg. of methyl testosterone and 100 mg. of stilbestrol. The complication cleared up rapidly on withdrawal of the drugs; one patient suffered from pruritus vulvae with atrophy of the labia majora. The total dosage administered was 1,575 mg. of methyl testosterone and 150 mg. of stilbestrol.

We believe that these by-effects are the result of stilbestrol rather than from methyl testosterone, especially since the type and frequency of reactions are similar to those seen with stilbestrol alone.

#### SUMMARY

1. A series of sixteen women treated for menopausal complaints is reported.
  2. Therapy consisted of a combination of methyl testosterone and stilbestrol.
  3. Dosage varied from 5 to 25 mg. of methyl testosterone and 2 to 3 mg. of stilbestrol daily.
  4. Symptoms of menopause were ameliorated or controlled.
  5. The vaginal smear demonstrated an original reduction of epithelial reaction of the mucosa with secondary improvement.
  6. No correlation between vaginal hydrogen ion concentration and smear was apparent in this series.
  7. There was no instance of excessive uterine bleeding during combination therapy.
  8. One patient showed a transient lowering of voice during therapy. No other evidence of masculinization was noted.
  9. By-effects of anorexia, nausea and vomiting occurred in a few cases. Pruritus and a papular eruption each was noticed in a single case.
- It is our belief that a combination therapy, such as outlined above, is of considerable advantage in certain selected cases of female menopause.

We wish to express our thanks to the Schering Corporation for the use of their

product, Methyl Testosterone, and to the Winthrop Chemical Co. for the use of their product, Stilbestrol (Cyrestrone).

We wish to express our appreciation to Dr. Charles H. Birnberg for his co-operation and kindness.

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SARCOMAS of the stomach vary in their macroscopic appearance depending on cellular type, cellular activity, location, and degenerative change. Lymphosarcomas usually differ from other sarcomas of the stomach in that they are for the most part endogastric.

From—"Carcinoma and Other Malignant Lesions of the Stomach"—by Waltman Walters, Howard F. Gray and James T. Priestley (W. B. Saunders Company).



# TECHNIC OF INSERTING THE STEINMAN PIN\*

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ON the Orthopedic Division of the New York City Hospital we still find many uses for the Steinman pin

shaft of steel approximately 7 inches long  $\frac{3}{32}$  of an inch in diameter, squarely bevelled to a point at one end and usually bluntly pointed at the opposite end. (Fig. 1A.)

This pin may either be drilled or hammered into a bone. Hammering has the advantage that the pin fits very snugly into the hole in the bone and is less apt to slide from side to side. On the other hand, when the pin is drilled into position we do not have the jolting shock of the hammer blows which, in addition to causing some discomfort, tends at times to displace the fracture fragments.

To hammer a Steinman pin into place we make use of a Steinman pin cap. (Fig. 1B.) This consists of a square headed machine bolt  $4\frac{1}{4}$  inches long,  $\frac{7}{8}$  of an inch in diameter, with a  $\frac{9}{32}$  of an inch hole drilled to a depth of  $1\frac{1}{4}$  inches at the far end. The cap is placed over the blunted end of the Steinman pin (or even a sharp end if both ends happen to be sharpened) so that it covers the proximal end of the pin for about an inch. With an ordinary surgical hammer the pin is driven into place by striking the squared head of the bolt.

To drill the pin into place we first used the small handle which fitted over the blunt end of the pin so that it can be rotated. This was very difficult and awkward because of the small size and poor purchase of the handle. If one takes the ordinary Steinman pin and fits it into a standard-sized hand drill with a universal chuck (c) it becomes an easy matter to drill the Steinman pin through any type of bone. Because of the squared point of the pin it almost acts like a steel drill in penetrating bone. In this way, one can insert the pin without disturbing the fracture fragments.

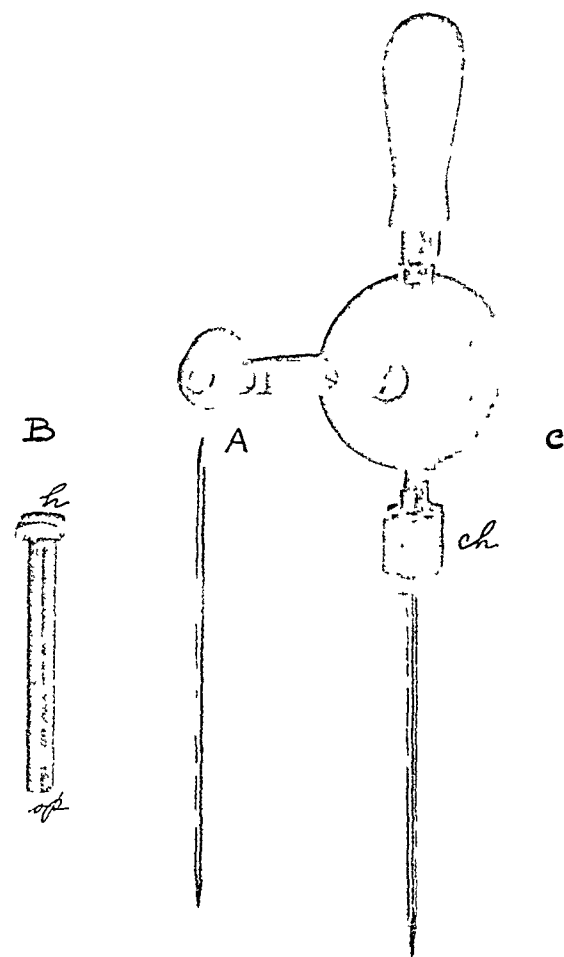


FIG. 1. A, Steinman pin; B, cap; C, hand drill with pin in position for insertion into bone; h, head of cap; op, open end of cap which fits over Steinman pin; ch, universal chuck which holds Steinman pin.

in the treatment of fractures. In the course of our experience we have made some useful modifications in the technic of inserting these pins which we hope may be of interest to other surgeons.

Our average pin is a chromium-plated

\* From the Surgical Service of Lyman W. Crossman, M.D.

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# Case Reports

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## SPLENIC ABSCESS WITH DRAINAGE AND RECOVERY\*

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AND

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**S**PLENIC abscess occurs with considerable frequency as is demonstrated by numerous references to the condition found in the literature. In 1879, Blanc presented a study of splenic abscess of malarial origin.<sup>1</sup> Grand-Moursel,<sup>2</sup> in 1885, collected fifty-seven cases; Kuttner,<sup>3</sup> in 1907, reported on 116 cases; in 1924, Silvestrini collected 150 cases; Wallace in South Africa reported to Billings that he had "either operated on or found at autopsy well over 100 cases of splenic abscess" and Billings himself reported on fifty-one cases in 1928;<sup>4</sup> and Walker<sup>5</sup> reviews thirty cases including one patient he personally treated surgically. There are numerous other contributions on the subject.

Abscess of the spleen frequently develops from latent systemic infection or as metastasis from some septic focus elsewhere in the body such as phlebitis, otitis, carbuncle, etc. Most writers on the subject seem to agree on the following etiologic classification with slight individual variation: (1) traumatic, (2) metastatic, (3) abscess following suppuration in the vicinity of the spleen.

A *traumatic abscess* of the spleen is chiefly the result of a suppurating, perisplenic hematoma following injuries producing a rupture of the spleen. Hematomas offer a favorable medium for the bacterial growth of germs in the general circulation or obvious foci of infection. Inlow<sup>6</sup> reported on twenty-four cases in which the etiologi-

cal factor was rupture of the spleen with secondary infection of the hematoma. Stab wounds or accidental punctures of the spleen may carry infecting organisms which produce an abscess and this is illustrated in one of Walker's cases in which an injury of the spleen took place in the course of nephrectomy for an infected kidney. Several observers believe that about 15 per cent of splenic abscesses result from a traumatic factor.

The greater percentage of splenic abscesses are concerned with *metastatic phenomena*. These following local or general infection. It seems that infection of the digestive tract is in particular a source, chiefly because of the high incidence of splenic abscess following typhoid reported by different writers to vary from 14 per cent to as high as 70 per cent. Our case followed phlebitis. Dr. Eliason reported a case following a peritonsillar abscess. Dr. Billings' case followed a carbuncle. A great variety of infectious conditions have preceded abscess of the spleen. The earlier writers reported malarial infection to be a prominent source of splenic abscess. Bacterial abscess is a common forerunner of this condition and abscess of the spleen has developed during the course of or following pneumonia, influenza, streptococcic infections, appendicitis, puerperal infections, intestinal amebiasis, the infectious diseases, anthrax, deep infected burns, otitis, mastoiditis, etc. Abscess from an

\* From Surgical Division "A" of The Jefferson Medical College and Hospital, Philadelphia, Pa. Read before the Philadelphia Academy of Surgery, November 3, 1941.

unknown cause or from an undetermined infection has occasionally been seen.

Abscess following suppuration in the vicinity of the spleen or by *contiguity* is not a common finding but represents a complication of a disease process in a related organ which extends itself to the splenic area and then into the substance of the spleen. This is illustrated by reported cases of abscess following rupture of a gastric carcinoma into the spleen, rupture of a hepatic abscess into the splenic area, perforation of a carcinoma of the colon into the spleen and secondary involvement of the spleen from a perinephric abscess.

A variety of conditions seem to predispose to abscess of the spleen and these include typhoid, malaria, tuberculosis, diabetes, local fatty degeneration, infarct, movable spleen, torsion, hemorrhagic infiltration and a "dysequilibrium between specific cellular action and general biological action due to intense functional hyperactivity in an infectious disease"<sup>1</sup> as in typhoid or any condition in which general or local resistance is diminished.

The pathogenesis of the condition is related to the etiological factor. As seen from the above paragraphs it may follow a direct route by *contiguity* or may be hematogenous via the veins and arteries. Embolic infarction is the probable process in the cases of endocarditis and typhoid. E. Calderera suggests that "the inflammatory process begins around the infarcted area and the latter becomes gradually infiltrated and undergoes purulent changes."<sup>8</sup> And this seems to bear out Kuttner in his theory of the occurrence of a "sequestrating" abscess in which particles of splenic pulp of variable size are found in the abscess cavity. While, from a clinical standpoint, a single abscess is usually found, the autopsy reports indicate "that multiple abscesses are more frequently found than the solitary variety."<sup>4</sup> Practically every organism, with the exception of the gonococcus, has been found in splenic abscess.

The symptoms associated with abscess of the spleen vary with the individual case

and are somewhat influenced by the causative factor. In certain cases the abscess may be so situated and of such size as to produce no pointed symptoms or it may be clouded by more prominent symptoms of a pertinent process of which the abscess of the spleen is merely a complication. The formation of the abscess may be acute or insidious in onset; it may quickly follow a primary infection; or the interval between its development may vary from a few weeks to a number of years. The location of the abscess will influence the symptoms. If its extension is toward the thorax, there will be diaphragmatic and pleural involvement characterized by pain of varying intensity, located in the left hypochondrium and lower chest, radiating to the back and upward to the left shoulder. If the abscess is located in the anterior surface or the lower pole, the symptoms will be more referable to the abdomen due to peritoneal irritation.

The general symptoms of suppuration such as fever, chills, sweats and leukocytosis are usually seen. Pain and splenic enlargement are usually present. There may be abdominal distention with marked muscular rigidity and tenderness in the upper left quadrant. The expansion of the thorax may be restricted in the lower left area. X-ray examination is illuminating, revealing the fixation of a higher left diaphragm, the displacement of surrounding organs by barium enema and the exclusion of the kidneys by pyelography. Exploratory puncture for diagnostic purposes is used by some but carries a possible hazard.

Treatment of the condition, in selected cases, is surgical. Splenotomy is the procedure most frequently employed and possibly offers the greater prospect for recovery. Splenectomy is the choice of operation in those cases which are made feasible by finding the spleen fairly free of adhesions and in which the condition of the patient justifies this more extensive technical operation. Several writers suggest the following surgical approach to a splenic

abscess, the selection of which is to be determined by the factors present in the individual case: (1) transpleural, (2) ab-

with the exception of the "usual diseases of childhood." She had borne one child with a normal labor; she had no miscarriages or



FIG. 1. This shows the x-ray picture of a flat plate of the abdomen. A large soft tissue mass is present in the upper left hypochondrium.



FIG. 2. The barium enema shows the marked displacement of the colon.

dominal and (3) retroperitoneal. In our case we used the abdominal route through a left upper rectus incision which, in the majority of instances, seems to offer the better exposure for the work to be done.

The prognosis is in definite relation to the condition with which the abscess is associated. Most of the cases in which no operation is performed terminate fatally. Different observers report varying mortality rates but with our present-day facilities for study, the condition of splenic abscess can be diagnosed and successfully treated in the majority of cases.

#### CASE REPORT

E. I., a white housewife, forty-eight years of age, was referred by Dr. Frank Jamison of Gloucester, New Jersey, to the private service of Dr. William T. Lemmon at the Jefferson Hospital on July 29, 1938. Her chief complaints were pain in the upper left quadrant of the abdomen for three weeks, fever and flatulent indigestion for six weeks. She was always in good health until her present trouble began

abortions, and she gave no history of previous cardiorespiratory, gastrointestinal or genitourinary symptoms. Her family history was irrelevant.

Seven weeks before admission she had an operation in another hospital for the removal of a dislocated semilunar cartilage of the left knee. She apparently made a normal recovery and was discharged from the hospital two weeks after her operation. The second day she was at home she had a sudden sharp pain in the region of Hunter's canal in the right leg. The extremity became swollen and tender in this area and she felt feverish. She went to bed and called her family physician who sent her back to the hospital where she was found to have a phlebitis of the right femoral vein. This was apparently successfully treated so that after ten days she was able to return home. Three days later she was seized with a sudden, sharp, severe pain in the upper left quadrant of the abdomen, just below the costal margin which was relieved by a hypodermic of morphine. Since then she has had continuous dull, aching pain in this area which becomes more marked when she moves or takes a deep breath. She seemed to improve and was able to be out of bed but on July 27 she again had an attack of severe pain in the upper

left quadrant which was radiated to the region of the left shoulder. This attack was accompanied by fever and chills. While blood cultures did not

leukocytes 11,800 with 91 per cent polymorphonuclears. The urine showed a trace of albumin and 10 to 20 pus cells to the lower power field.

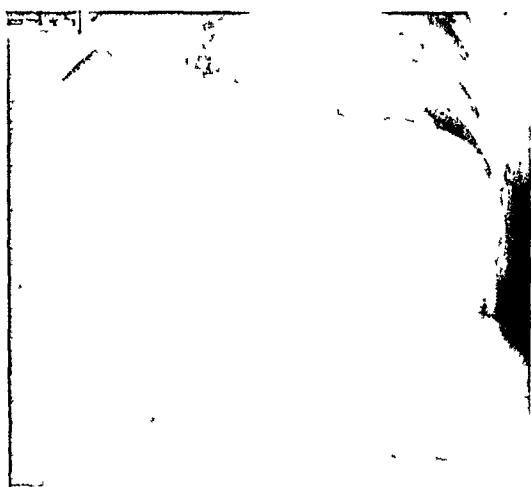


FIG. 3. The above picture of a flat plate taken four and one-half months after operation shows the abdomen to be "essentially negative."

reveal a blood stream infection Dr. Jamison reported that she had run a varying degree of fever from the time of her phlebitis until her present admission. Dr. Lemmon was asked to see the patient in consultation after which she was admitted. It is only fair to mention that Dr. Jamison had already made a diagnosis of splenic infarct clinically.

*Physical examination* revealed the patient to be an obese white female lying in bed in some apparent pain. There was no dyspnea, cyanosis or jaundice. Her temperature was 100.6°F., pulse 98 and respirations were 24. The tongue was coated. Respiratory movements were somewhat restricted, particularly on the left side. Lung expansion was shallow. There were no râles or adventitious sounds in the chest. The abdomen was thick from obesity and somewhat distended in the left hypochondrium. There was marked muscular rigidity and tenderness in this area. No definite mass could be felt. Deep inspiration greatly aggravated her distress. The area of splenic dullness to percussion was increased and caused considerable pain. The area of liver dullness was increased downward but the liver could not be felt due to the thickness of the abdominal wall. Peristalsis was slightly hyperactive. There was thickening along the course of the right femoral vein but no redness or tenderness. The scar of the operation on the left knee was well healed. Hemoglobin was 75 per cent, red blood cells 4,120,000,

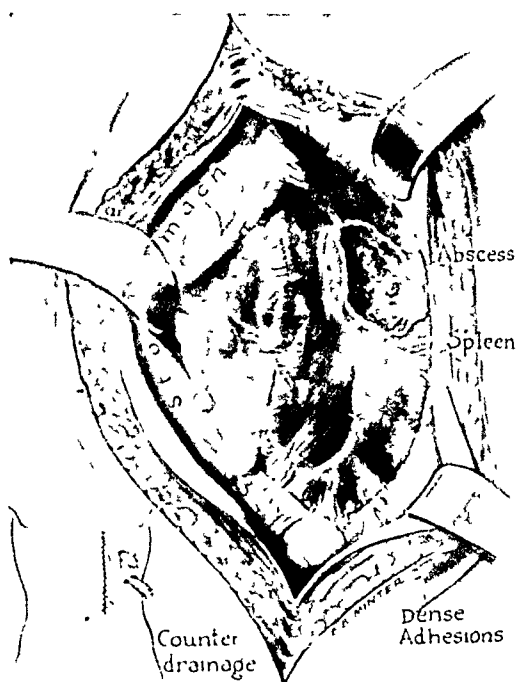


FIG. 4. A diagrammatic drawing which shows the relative location of the abscess, the enlarged spleen displacing the stomach and colon and the newly formed adhesions. The insert shows the site of incision and the point of counter drainage.

Otherwise, the general examination was negative.

On the day after her admission x-ray examination of the abdomen with a flat plate and a barium enema were done. Dr. Karl Kornblum reported as follows:

"Abdomen: The flat films of the abdomen show definite enlargement of the right lobe of the liver. The right kidney is clearly outlined. The left kidney is not visualized. In the renal area there is a vague soft tissue mass which appears to be displacing the stomach to the right.

"Barium Enema: Examination of the colon by barium enema shows no evidence of obstruction. The splenic flexure is definitely displaced downward and to the right by a large soft tissue mass in the upper left abdomen. The entire colon filled normally and the contents entered the terminal ileum. One film was made. After evacuation, about twenty per cent of the contents remain distributed throughout the colon. Nothing further noted. Two films were made.

"Interpretation: There is a large soft tissue tumor mass in the left upper quadrant. This is more than likely due to enlargement of the spleen. We cannot absolutely exclude its origin in the left kidney, since we do not visualize this organ. The splenic flexure is somewhat displaced downward and the stomach is being pushed to the right by the mass. There is enlargement of the right lobe of the liver."

The following is a report of kidney study which eliminated suspicion of that organ:

"Retrograde Pyelography: The flat film with catheters in both ureters gives no additional information.

"Retrograde Pyelogram: Retrograde pyelography done on the left side shows the pelvis to be fairly normal in appearance, size and shape. The left kidney is faintly outlined and is normal in position.

"We are inclined to believe that the mass in the left upper quadrant is not primarily in the kidney.

"Interpretation: Negative pyelography on the left side. Tumor mass apparently does not arise in the left kidney."

Her temperature for the first five days in the hospital was below 100°C. but varying between that figure and 97°C., and with a pulse rate between 98 and 72. The muscular rigidity persisted and the tenderness became more marked and localized just below the left costal margin while the pain was progressive and continuous. A diagnosis of splenic abscess was made and operation done on August 5, 1941 under cyclopropane-ether anesthesia with the patient receiving a hypodermic of morphia (gr.  $\frac{1}{4}$ ) and atropine sulfate (gr.  $\frac{1}{150}$ ) one hour beforehand.

**Operation.** The abdomen was opened through a left upper rectus incision. The liver was enlarged and the gallbladder was normal. A large mass was present in the upper left quadrant which was adherent to the parietal peritoneum. These adhesions were freed by blunt dissection and the mass was confirmed to be the spleen which was greatly enlarged and adherent to the greater curvature of the stomach and the transverse and splenic portions of the colon. These structures were displaced downward and medially by the splenic enlargement. The omentum was greatly indurated. The anatomical landmarks were obliterated by the extensive induration and newly formed adhesions. The diaphragmatic surface of the spleen was exposed and the field well packed

off. The abscess was opened and about a half a cup of pus aspirated. It was thick yellowish and contained pulp-like shreds of splenic tissue. Two iodoform gauze drains were placed in the abscess cavity and over the adjacent surface of the spleen and medially covered with rubber tissue, and then all of these were brought out through a stab-wound in the upper left flank. (The size of the abscess was roughly about 10 cm. long, 7 cm. wide and 3 to 5 cm. deep.) (Fig. 4.) The wound was closed in layers with a rubber tissue drain down to the fascia. A smear of the abscess contents showed *Staphylococcus albus*.

The first four postoperative days were quite stormy. On the second of these days her temperature was 104.6°F. and pulse 140. Use of the oxygen tent, the Wagensteen suction apparatus, continuous venoclysis and opiates improved her condition. Drainage was profuse. On the third postoperative day her temperature was below 100°F. most of the day but on the fourth day she had a sharp rise of temperature to 108°F. with profuse sweating, cyanosis and rapid shallow respirations. In a short while, however, the temperature dropped to less than 101°F. From this point she gradually improved. Repeated blood cultures were negative. The oxygen tent was removed on the sixth postoperative day and she was then able to tolerate fluids by mouth. The drains were shortened and finally removed on the twelfth postoperative day. Healing of the wound was delayed by an extensive infection of the superficial fat. She continued to run a low-grade temperature and had a considerable quantity of drainage from the wound infection for about thirty days. Finally, this subsided and she improved generally. She was discharged on September 17, 1938, forty-two days after operation.

Dr. C. J. Bucher's pathological report on the operative specimen was as follows:

"Histology: Sections consist of tissue from the spleen. There are a number of hemorrhagic areas. There is considerable necrosis and the entire spleen is infiltrated with polymorphonuclear leukocytes. There is a loss of the architecture, so that from the sections it cannot be recognized as spleen. As much as I can say from the tissue submitted, it is an inflammatory lesion."

On December 12, 1938 re-examination of the patient's abdomen by x-ray revealed that it was "essentially negative." (Fig. 3.)

At this time, three years after her illness, she is in good health and active. She has a small incisional hernia at the lower part of her incision which causes her no discomfort. We consider her a case in which splenotomy for splenic abscess was done and recovery followed.

#### SUMMARY

A study of the literature reveals that splenic abscess is not a condition encountered infrequently. With the use of all facilities for study the diagnosis should not present great difficulty. Splenotomy is most generally employed for surgical treatment of a splenic abscess but splenectomy is desirable in selected cases. We have

reported a case of abscess of the spleen in which recovery followed operation.

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By splenectomy, . . . a considerable portion of the blood which burdens the varices is eliminated, and the danger of hemorrhage is diminished. From—"Surgical Physiology"—by Joseph Nash (Charles C. Thomas).

# BLOOD WITHIN THE BRONCHI FOLLOWING HEAD INJURIES\*

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**D**ESPITE the fact that the early respiratory disturbances and abnormal lung signs that occur in connection with head injuries have been ascribed most often to trauma of the medullary respiratory center, other, equally important, non-neurological factors may play more than a minor rôle in the production of these respiratory signs and symptoms.

Particularly is this so when there is bleeding from the nose, ear or mouth. Consequently, if the entire clinical picture is not fully understood and proper treatment instituted, many patients, who should live, will die.

## REPORT OF FATAL CASES

Two of the patients were seen at a time when our conception of the mechanism involved in the production of such deaths was decidedly undeveloped; and, even when the third patient arrived, we still only partially understood the cause of the respiratory symptoms.

**CASE I.** This patient had sustained a head injury which rendered him unconscious and produced bleeding from the nose and mouth. Although consciousness was partially regained on entry to the hospital where he was placed in the semi-Fowler posture, irritability was pronounced, and, the breathing became increasingly labored, rapid and noisy. The course was continually downhill, and within eighteen hours the patient was dead.

**CASE II.** This patient had received a type of injury similar to that in Case I, but in addition to the preliminary unconsciousness and irritability with noisy labored breathing, this man was coughing and expectorating bloody, foamy material. On a basis of the latter symptoms an

associated chest injury was suspected, but it was neither proved nor disproved clinically. Death occurred twelve hours later.

As I look back now I am very much surprised that in neither of these cases was much thought given as to just why the patients died. The deaths were more or less taken for granted.

**CASE III.** This patient, who had been knocked from a ship and rendered unconscious, presented a clinical picture so identical with the previous patient that a tentative diagnosis of combined head and chest injury had been made, and the semi-Fowler posture employed. Yet, notwithstanding the shallow, rapid, labored, noisy breathing, the impaired percussion note, and the diffuse bilateral râles and rhonchi, I could find no objective evidence of external chest injury. There was no subcutaneous emphysema, no rib crepitation and no sign of pneumothorax or hemothorax.

Consequently, I was inclined to interpret the chest condition as due solely to a head injury from which blood was dripping down into the lungs,<sup>1,2,3</sup> and, as therapy, recommended change of posture and bronchoscopic removal of the intrabronchial blood.

There was a difference of opinion among the consultants, however, and my idea was not accepted. The neurosurgeon was quite emphatic in his contention that the chest signs were attributable to lung injury and maintained that stuporous head injury patients might swallow blood but would not aspirate it. Objections were also raised to the making of a chest plate for fear that any slight movement would have a deleterious effect. But at any rate, four hours later the patient was dead.

**Coroner's Autopsy:** There was no air or blood in the pleural cavity, no surface injury of the visceral or parietal pleura, and no break in the bony framework of the thorax. The surface of

\* From The Thoracic Surgical Departments of St. Mary's and Mary's Help Hospitals, San Francisco.



both lungs was of a blood red color, while the lungs themselves were solid and heavy. On cut section, free blood ran out from the bronchi



FIG. 1. Specimen of cat's lungs following experimental head injury. The massive dark areas in each lung indicate the extensive collection of free blood within the air channels. Note the marginal obstructive emphysema at the apices.

and air spaces. The coroner's official opinion on the thorax was: "Lung injury due to chest trauma."

*Case Discussion:* It seemed to us that the postmortem diagnosis had been arrived at without sufficient substantiating evidence. Was the mere presence of blood in the bronchi and air spaces indicative of lung injury and pulmonary bleeding, or could the blood have come from another source? Could it have drained, as we believed, from the injured head into an intact lung? These questions are of such clinical importance that we sought the answers in the experimental laboratory.

#### EXPERIMENTAL STUDY

Seven cats were struck on the head with an iron bar to render them unconscious and produce bleeding from the nose and mouth. The details of the experiment are reported elsewhere,<sup>4</sup> but suffice it to say that six of the seven animals showed free blood in varying qualities within the bronchi and lungs even though no chest injury had been sustained. (Fig. 1.)

As a result of these experiments and other observations which shall be discussed later, we can state that blood from head injuries drains down along the posterior nasopharynx, chiefly by gravity, into the larynx and lumen of the tracheobronchial tree. By partially or completely plugging the major or minor bronchi, the collected blood initiates the onset of obstructive pulmonary emphysema, or, as the case may be, obstructive atelectasis.<sup>5</sup> It most often occurs in the unconscious, stuporous and semiconscious, but may be found in others.

The consequent impairment of air flow reduces the vital capacity and increases the respiratory and circulatory rates. The coughing and bloody expectoration represent an attempt on the part of the lung to restore the normal air flow by evacuating the bloody material which drained down from the injured head. But if this evacuation is insufficient, and, if the vital capacity is reduced beyond the safety level and kept there over too long a period, death will ensue.

#### GENERAL DISCUSSION

We have not had an opportunity of passing the bronchoscope on a head injury patient who showed abnormal lung signs and respiratory distress. How then can we say that the observations on the cat apply equally well to man and that blood will run down from an injured head into the lung? Is not a radical paranasal sinus operation a form of bleeding head injury? And does the blood from the operative site find its way into the lumen of the tracheobronchial tree?

We bronchoscoped two such patients immediately after the completion of sinus operations, and found large quantities of blood within the bronchi of both lungs despite the fact that a nasal-throat plug had been used during the sinus procedure with the aim of preventing aspiration. Both of these patients showed only negligible amounts of filmy blood on the posterior pharyngeal wall, and being classified as "dry cases," it is no wonder that the nasal

surgeon, looking upon the bronchoscopy as an unnecessarily academic procedure, was amazed at the large quantity of blood which was actually present within the tracheobronchial lumen. The blood was removed by bronchoscopic suction and the recoveries were uneventful. Let us re-emphasize that meager amounts of blood in the pharynx of head injury patients is a very poor index of the amount of blood within the tracheobronchial lumen. There is only one way to be positive, that is to look.

#### CONCLUSIONS

1. In head injuries with bleeding from the nose, mouth, ear or base of the skull, free blood can drain into the tracheobronchial tree and produce bronchial obstruction with abnormal lung signs and symptoms.

2. These abnormal lung signs are sometimes mistakenly interpreted as evidence of medullary trauma, or even as indicative of concomitant chest injury.

3. I believe that many of the bleeding head cases in which the patients die would live if this bloody material were removed, or, better still, prevented from entering the lung by the employment of proper postures and the use of suction.

4. From the standpoint of preventing these serious lung complications, the semi-Fowler position should be discarded for head cases, and instead, the foot of the bed should be elevated and the head of the bed lowered.

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# CARCINOMA OF THE ILEOCECAL VALVE\*

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REPORTS of neoplasms in the ileocecal valve have been presented so infrequently, that tumors in this situation are considered of rare occurrence. For this reason, we believe that the record of our case including a review of the subject is of value.

An appreciation of lesions in the region of the ileocecal junction might best be obtained if the embryology and physiology of this interesting part of the gastrointestinal tract is considered. Keith makes a comparison between the complex structure of the ileocecal junction in the higher mammals with that of the human. In an early embryonic stage, the mammal presents an additional sphincter which separates the cecum from the colon. Later, this sphincter merges with the ileocecal junction. Persistence of this vestige is sometimes found in the human. This may be considered as a development of functional specialization in this region. Furthermore, Keith notes that the relationship between the stomach and ileocecum is dependent upon the feeding habits in which one or the other is either simple or complex in structure. For example, in the horse, the structure of the cecum is complex as compared with the simple nature of the stomach. The reverse holds true in ruminant animals. In the early stages of human embryonic life, the hind gut consists of a straight tube which soon differentiates. The future cecum located in the left side of the abdomen, grows so rapidly that the junction with the ileum forms a right angle. Development proceeds with rotation of the large gut around its long axis toward the right.

The physiology of the ileocecal sphincter consists of a valve-like mechanism which

allows for intermittent emptying of the ileal contents into the cecum. Well developed circular muscle fibers in the sphincter alternately contract and relax, depending on the stimulus involved. Fasting slows the expulsion of ileal fluid while the swallowing of food or emotional states increase the frequency. It has been definitely proved that only great pressure will open the ileocecal valve from the cecal side whereas a comparatively lower pressure from the ileum is required for the propulsion of its liquid contents. These phenomena have been directly observed in man by visualization through a cecal fistula. The sphincter presents itself with a central aperture in a small papilla. A marked resistance was encountered when insertion of the finger was attempted through the papillary opening. Under direct vision it was also observed that the flow of fluid from the ileum into the cecum was intermittent and affected by the stimuli previously mentioned. The function of the ileocecal valve is twofold: It serves to hold back the ileal fluid content until digestive and absorptive processes are completed and bars the entrance to the ileum from a return flow from the colon with its detrimental, highly contaminated bacteria.

Consideration of the etiology and incidence of carcinoma in the gastrointestinal tract includes the significance of the common sites of occurrence. These locations are the regions of greatest constriction or the curvatures—cardiac end of the stomach, pylorus, ileocecal region, colic flexures, rectosigmoid and anorectal pouch. On the other hand, neoplasms of the small intestine are rare. According to Sherwood, the etiology of gastrointestinal malignancy is

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the "... constant irritation and increased muscular action or spasm at the points of greatest constriction." It is important to note that trauma to the ileocecal valve is much less than that to the pylorus where the trauma resulting from irritating gastric juice and solid food is greater. Perhaps this accounts for the comparatively lower incidence of neoplasms in this region. Adam is of the opinion that chronic irritation with inflammation is most often the causative factor. With these views in mind, we would expect to find carcinoma of the ileocecal valve more prevalent. Ewing lays stress on the anatomical factors in the etiology. Muir states that the most common site for these malignancies is in the upper region of the rectum and next in the order of their frequency are the flexures and the ileocecal region.

Various writers differ greatly in estimating the incidence of ileocecal valve growths. It is apparent that this confusion lies in the statistical method wherein the differentiation of cecal, ascending colon and confined ileocecal valve malignancies are in most instances classified under a collective heading as "ileocecal" tumors. As a result, the recorded incidence varies from 1.1 per cent (Treves quoted by Carnot) to 24.2 per cent (DeBovis). Furthermore, peremptory evidence of the source of the neoplasm is most difficult to ascertain because of the fact that these lesions are nearly always seen at a late stage in the course of the disease. This observation was made by Adam who reviewed 132 "ileocecal" cancers of which only twenty seemed to have had their origin in the ileocecal valve. Some writers (Desmaret, DeBovis et al.) believe that the great majority of cases originate in the ileocecal valve and subsequently spread. Others (Loubart and Cugnier) found the percentage to be low. Their deductions were made from the study of a large number of cases of which only a few were determined with any degree of certainty as having been primary in the ileocecal valve. Wapshaw's statistical review of 455 colon malignancies from the Glasgow Western

Infirmery over a ten-year period (1927 to 1937) noted the incidence of 1.32 per cent ileocecal valve carcinomas and 8.35 per cent cecal malignancies. In this series, only sixty were autopsied and one case alone was definitely proved to be a primary ileocecal valve carcinoma. Wapshaw concluded that the ratio of ileocecal valve to cecal malignancy was 1 to 6. It is interesting to note the experiment of Bargen et al. which may explain the limitation of cephalad malignant spread from the cecal side of the sphincter. The submucous injection of India ink solution in the cecum was limited in its dissemination to the papillary edge of the sphincter, whereas the same limitation was observed when the injection was made on the ileal side. This seems to indicate the presence of a lymphatic block or barrier at the summit of the ileocecal papilla.

The pathological development of carcinoma of the ileocecal valve is generally one of three types: (1) Adenocarcinoma—most common; extends rapidly toward the cecal side and has an ulcerative tendency; (2) fibrocarcinoma—stenosing, annular, constricting type; and (3) gelatinous adenocarcinoma—least common; it shows a tendency to extensive ulceration, central slough and large growth.

The concensus of opinion concerning the tendency toward metastasis is that it is greater for growths in the ileocecal region than elsewhere in the colon. This is explained on the basis of a richer vascular and lymphatic supply in the proximal area of the colon. There appears to be a tendency for an associated or secondary intussusception in the presence of ileocecal valve growths. Sherwood reported three cases and Wapshaw one case of this type. Isolated reports of ileocecal tumors other than carcinoma include carcinoid (Christopher) and lymphosarcoma (Sherwood).

The diagnosis of ileocecal valve carcinoma is difficult and usually impossible. The explanation rests with the fact that it is only when the disease is far advanced that symptoms of obstruction become

apparent. Early manifestations are vague and vary from digestive disturbances to recurrent attacks of abdominal pain. Without exception, all cases reviewed by the authors had a common finding in that the diagnosis was determined postoperatively. Adam's case report states that a gastrointestinal series taken a few months before operation was negative for any ileocecal pathological condition.

Methods in treatment, as determined from the literature, are fairly uniform. When the patient's general condition permits, a resection of terminal ileum, cecum and ascending colon, with ileotransverse colon anastomosis is performed. In some cases a two-stage operation is a safer procedure and a palliative ileostomy is performed.

#### CASE REPORT

M. C., No. 795, a seventy-five-year old male, Italian iceman, was admitted to the medical ward August 26, 1940, with a complaint of lower abdominal pain of three weeks' duration. Vomiting occurred twice since the onset of present illness, and the patient had eaten but little because food aggravated the pain. There had been a long history of constipation. Blood had never been noticed in the stools. Herniorrhaphy had been performed in 1920 and the patient suffered with asthma since 1932.

Physical examination revealed the patient to be an adult male not acutely ill or in evident pain. He was pale and moderately emaciated. Aside from the presence of a few moist crackling râles in both bases, distant heart sounds and a faint systolic mitral murmur, the local condition (abdomen) only was of interest. The abdomen was symmetrical. There was no distention or rigidity, but there was slight rectus spasticity over both lower quadrants. Active peristalsis was present on palpation and intestinal loops were felt. Peristaltic rushes could also be palpated and were associated with pain which moved from left toward the right over the lower portion of the abdomen. The liver, kidneys and spleen were not palpable. Digital examination of the rectum revealed the presence of a large prostate but no masses were present.

The provisional diagnosis following examination was (1) partial intestinal obstruction, (2)

internal hernia, (3) diverticulitis and (4) bronchiectasis.

For the following three weeks the temperature remained within normal limits. The pulse ranged between 68 and 100. Abdominal pain persisted, was intermittent and of the same character as on admission. Marked anorexia continued. It was agreed that an obstruction involving the small intestine was present. The x-ray gastrointestinal series revealed the following positive findings: "One of the loops of the ileum appears narrow. At 24 hours, barium is distributed from the cecum to the rectum. The transverse colon is low and unevenly filled. The sigmoid is redundant and a number of diverticuli are present. A detailed study of the colon and ileum is suggested."

A few days later, x-rays following a barium enema revealed that the barium passed readily from rectum to cecum. There was no definite pathological condition in the colon and no reflux into the terminal ileum. The gastrointestinal series was repeated on September 12, 1940, and the following noted: "Serial studies after ingestion of the barium show. At 3 hours most of the barium is clumped in the region overlying the pelvis. At 4, 5, 6 and 7 hours there is noted marked distention of bowel which is presumably small intestine. The conclusions are, (1) Intestinal obstruction, (2) The location of the small bowel rather low in the pelvis is suggestive of a possible internal hernia located in this region as a causative factor." Films taken twenty-four hours and forty-eight hours after ingestion of barium showed passage of the barium into the large bowel as evidenced by barium in the rectum. However, the small bowel still contained a large amount of barium and showed marked distention. Obstruction was apparently of partial nature. A flat plate of the abdomen taken two days later still showed the presence of barium distributed throughout the large bowel and also evidence of distention of the small intestine.

On September 14, 1940, a Miller-Abbot tube was passed through the nose and its progress followed by fluoroscopy. Four hours later the tip of the tube had passed into the duodenum. The cuff was inflated and the tube connected for Wangenstein suction drainage which functioned satisfactorily. In spite of this, the patient continued to have abdominal pain and the distention increased slightly. A blood transfusion (500 cc.) was given. On the following day,

September 15, 1940, laparotomy was performed through a left lower rectus incision. A distended loop of small intestine was traced

ness and diminished breath sounds in the right axilla and back with coarse moist râles throughout the chest. X-ray showed a pneumonia of the



FIG. 1. Adenocarcinoma of ileocecal valve. The ileocecal valve presents on its mucosal surface an irregular firm nodular growth which appears hemorrhagic and infiltrates the wall.

proximally to the ileocecal valve and it was noted that the small bowel was markedly dilated in its entirety. The colon was collapsed. A small tumor mass was found confined to the ileocecal sphincter. It felt very firm in consistency and the valve failed to admit the tip of the small finger. The serosa in this region appeared normal in color and consistency. There was no local evidence of inflammation or metastasis. Peritoneal fluid was present in normal amount and quality. In view of the patient's advanced age and poor general condition it was deemed urgent to complete the operation in the shortest possible time. A Witzel ileostomy about 15 cm. from the ileocecal valve was performed and the tube brought out through a stab wound in the flank. The abdomen was closed in layers. The immediate postoperative condition was excellent. The ileostomy tube functioned satisfactorily as did the Miller-Abbot drainage.

On September 17, 1940, a flat plate of the abdomen showed no evidence of obstruction. There was a moderate degree of distention and the tip of the tube was localized in the intestine in the right lower quadrant. The same day, the temperature suddenly rose to 108°F., pulse 92, and audible tracheal râles with a hacking cough were present. Examination also revealed dull-

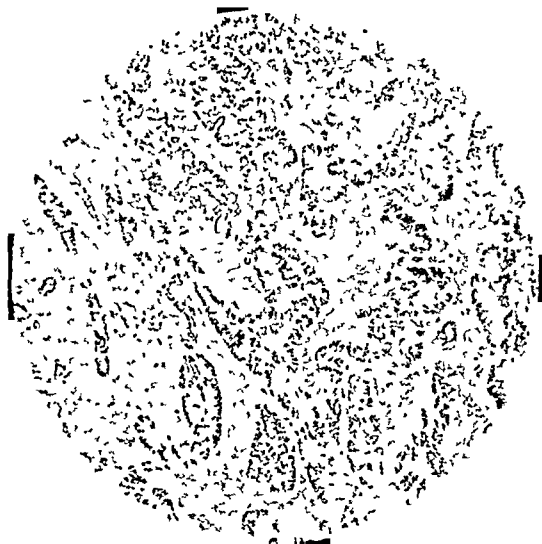


FIG. 2. Abortive glandular acini lined by an immature type of epithelium invading the musculature—adenocarcinoma.

right base. Auricular fibrillation was verified by electrocardiogram tracings. In spite of blood transfusion and other supportive measures, the patient went downhill and expired the following day. The autopsy was limited to the operative incision and abdominal viscera only. The pertinent findings were as follows:

"The ileocecal valve presents on its mucosal surface an irregular firm, nodular growth which appears hemorrhagic and infiltrates the wall. (Fig. 1.) On the inferior surface of the right leaf of the diaphragm there is a hemispherical soft nodule which is friable. The anatomical diagnosis is carcinoma of ileocecal valve, metastasis to the diaphragm and congestion of the liver. The cause of death is (probably) pneumonia." Microscopic section of the growth (Fig. 2) showed an adenocarcinoma.

#### SUMMARY

A review of the literature on carcinoma of the ileocecal valve is presented. The low incidence of carcinoma at this site is probably due to the inclusion of all growths in this region under one classification in previous statistical surveys. Embryological and physiological factors are considered as

being of possible etiological significance. A case history of primary ileocecal valve carcinoma is recorded.

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# TRAUMATIC HEMORRHAGIC CHOLECYSTITIS\*

## WITH HEMATEMESIS AND SHOCK AS THE PRESENTING SYMPTOMS

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**A**CUTE external trauma to the biliary system giving rise to hematemesis as the essential clinical complaint has been described in the literature only occasionally. Hermanson and Cabitt<sup>1</sup> reported an unusual cause for hematemesis, following trauma to the liver, and call attention to similar infrequent causes. In their case, the mechanism of the hemorrhage, masked at operation by the presence of only an apparent superficial tear, revealed at necropsy a hematoma underneath the healed superficial tear with a direct communication between the portal vein and the larger bile ducts. Hawthorne, Oaks and Neese<sup>2</sup> reported a similar case of liver injury with hematemesis apparently due to a cavity and hematoma deep in the substance of the liver, that continued to necrose and bleed through a large biliary duct until healing finally occurred. Exploratory laparotomy revealed no tears in the bile ducts or liver, so that the above was considered to be the only logical explanation for the continued bleeding through the biliary channels. Thorlakson and Hay<sup>3</sup> report a case of trauma to the liver that was accompanied by melena but not by hematemesis. At necropsy the findings were similar to those of Hermanson and Cabitts'. Other similar cases with melena have been reported, but none of these was accompanied by hematemesis.

In the case herein reported, the source of the hemorrhage was apparently extrahepatic and limited to the gallbladder since cholecystostomy with simple mechanical decompression led to a spontaneous recovery with no recurrence of the hematemesis. The aforementioned cases differ

from the case being presented, in that the essential pathological condition giving rise to the hematemesis was in the liver, whereas the essential pathological condition in this case was in the gallbladder, the source being a rupture of a branch of the cystic artery.

Sheddon and Johnston<sup>4</sup> state that the liver is more frequently injured than any other solid organ, yet rupture of the liver is one of the rarest reported surgical emergencies, appearing approximately once in every 1,300 cases brought to an emergency hospital. Traumatic injury of the gallbladder is apparently much less frequent. Monihan<sup>5</sup> found that the right lobe of the liver is injured six times more frequently than the left. Pickworth<sup>6</sup> states that rupture of the liver accompanied by shock is no contraindication to laparotomy, in fact continued shock is prime indication for immediate surgery. Thorlakson and Hay<sup>3</sup> report only three cases of rupture of the liver out of 3,900 accident cases in five years at the Winnipeg General Hospital. In twenty years, out of 200,000 general admissions, only eleven cases of rupture of the liver were noted. Rudberg<sup>7</sup> found only forty-one collected cases of traumatic rupture of the bile ducts in the literature up to 1921. Linormat<sup>8</sup> noted only twenty-four cases of traumatic rupture of the gallbladder itself. Taylor<sup>9</sup> reported an instance of nontraumatic hematemesis of biliary origin arising from a ruptured aneurysm of the hepatic artery communicating with the gallbladder. Considering the paucity of reports of injury to the liver or gallbladder causing hemorrhage into the intestine by way of the common bile duct, it is obvious

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that the condition is uncommon. No reports have been found in the literature in which a traumatic hemorrhagic hydrops of the gallbladder has presented itself with hematemesis and shock, as noted in the case herein reported.

#### CASE REPORT

A fourteen year old white girl was admitted on March 27, 1940, to the Illinois Research and Educational Hospital with a history of a fall on her right side six weeks prior to admittance. At the time of the fall she was carrying a jar of jelly in her right coat pocket. The injury had been followed by an intermittent pain in the right upper quadrant and right shoulder, accompanied by nausea and vomiting, slight fever, dark stools and tenderness in the right upper quadrant of the abdomen. Just prior to admission the patient had vomited profuse quantities of bright red blood and had become progressively more pale and weak within the period of a few hours.

Physical examination upon entrance revealed a pale, apprehensive, fourteen-year old white girl, apparently acutely ill. The temperature was 100°F., pulse 140, respirations 22, blood pressure 108/60. The essential pathological findings were abdominal and consisted of a tender lemon-sized mass in the right upper quadrant, moderate rigidity of the right rectus muscle, slight distention and normal peristaltic sounds. Rectal examination was negative except for dark red blood on the examining finger.

*Laboratory findings* revealed a hemoglobin content of 6 Gm; the red blood count was 1,700,000 and the white blood count 12,000. The urine was alkaline in reaction and negative except for an occasional granular cast. The platelets, coagulation and bleeding times were normal. The prothrombin activity was 100 per cent of normal and the ascorbic acid content of the blood was .45 mg. per cent.

The patient was obviously suffering from shock secondary to hemorrhage; in view of the hematemesis, the source of the bleeding was thought to be from the proximal portion of the small intestine, although we were unable to explain the presence of the mass which appeared to be gallbladder. In view of the limitation of the peritoneal findings to the region of the gallbladder, the patient was given a blood transfusion and treated conservatively. A daily blood transfusion for three days brought her red

blood count up to 3,090,000 cells, and hemoglobin to 7.5 Gm. Her general condition improved with a pulse of 90 and a blood pressure of 120/72. However, on the third day after entrance, the patient had an acute exacerbation of the local findings with marked muscle spasm and acute tenderness over the right upper quadrant mass, which appeared to be somewhat larger than on admission. This exacerbation, with development of muscle spasm was suggestive of a slowly developing perforation of the intestine; therefore, emergency operation seemed indicated.

At operation the gallbladder was markedly distended and presented into the wound. Exploration of the abdominal cavity revealed no perforation of a viscus or any obvious source of the bleeding. There was a slight induration in the dome of the liver over an area located in the region of the gallbladder. We could not be certain whether or not there might perhaps be a hematoma within the liver, or whether this mass was somewhat artificial, being caused by the distended gallbladder. Aspiration of the gallbladder revealed thick, black, liquid old blood. Palpation revealed an indurated, echymotic area alongside the neck of the gallbladder which presumably was the site of rupture of a branch of the cystic artery with the formation of a hematoma in the wall of the gallbladder and escape of blood into its lumen. Blood clots could also be felt in the common duct which was markedly distended but contained no stones. Accordingly, a cholecystostomy was done evacuating the old blood from the gallbladder. A small piece of tissue was removed from the gallbladder for biopsy. The wound was closed around the tube in the usual manner. The postoperative course was uneventful and the patient was discharged on the eleventh postoperative day. The pathological report of the gallbladder wall showed swollen engorged villi but nothing else of significance. The muscularis and serosa were edematous and showed early fibrosis with many new vascular channels. Three months after operation cholecystography revealed no visualization of the gallbladder. The patient has been symptom free since operation one year ago, and at the present time has a normal blood count.

#### COMMENT

From a consideration of the statistical data in this survey, hematemesis following crushing, nonpenetrating injuries of the

biliary tract probably occurs in less than 2 per cent of that type of injury. The patient herein discussed was a fifteen-year old girl in whom a traumatic nonpenetrating injury to the gallbladder resulted in hemorrhage into the lumen of the gallbladder. The bleeding presented itself clinically as a massive hematemesis with the patient entering the hospital in shock. At emergency operation active bleeding was not observed but the source of the hemorrhage appeared to be a rupture of a branch of the cystic artery, as suggested by the presence of an indurated ecchymotic area alongside the neck of a gallbladder markedly distended with liquid old blood. Although the source of hemorrhage in most instances of bleeding from the biliary tract is usually a laceration of the liver, this possibility is presumably ruled out (on empirical grounds) in the patient herein discussed by the fact that cholecystostomy resulted in cessation of bleeding. No definite preoperative diagnosis was made in this patient. The history of trauma to the right upper quadrant followed by localized peritoneal findings and a mass in that area, combined with hematemesis and shock, led us to the presumptive diagnosis of a crushing wound of the jejunum with intramural and intraluminal hemorrhage. However, the sudden increase in pain, tenderness and muscle spasm in the right upper quadrant was so suggestive of a local peritonitis (which obviously might become diffuse) that we deemed emergency operation strongly indicated. The appearance of early signs of peritonitis suggested that a hematoma in the crushed wall of the intestine had paved the way for a gradual perforation of the intestine with consequent escape of contents into the peritoneal cavity. Since six weeks had elapsed since injury, the development of peritonitis at this time would have to be explained on the basis of the presence of some type of necrotizing process as suggested above, or by rupture of an abscess which might have formed around a small perforation sustained at the time of injury. The fact that the patient had been bleeding for six weeks following

injury and has been perfectly well with a normal blood count for over a year post-operatively suggests that the operation contributed to the patient's recovery. The actual mechanism of relief afforded by cholecystostomy cannot be explained except that the favorable influence (if existent) was in some way related to correction of distention of the gallbladder by cholecystostomy. Just why distention of the gallbladder should contribute to recurrent hemorrhage from a laceration in the gallbladder wall cannot be explained unless distention interfered in some way with the return flow of blood from the gallbladder. If this is true, the source of bleeding should be venous, not arterial. This would appear unlikely in view of the fact that small veins of this type tend to thrombose, but blockage of venous return by distention might aggravate the tendency to dislodge clots.

It is evident that bleeding from the biliary tract may present itself clinically as hematemesis or melena by passage of blood through the cystic or common bile ducts. As stated previously, hematemesis arising from the biliary tract usually results from injury to the liver itself, but is nevertheless uncommon. The production of hematemesis by this mechanism is dependent upon certain conditions. For example, it is necessary that the laceration in the liver be sufficiently severe to involve fairly large bile ducts as well as vessels. Moreover, the laceration must not extend through the capsule; if it did, the blood would escape through the torn capsule into the peritoneal cavity. When the capsule is intact and a major bile duct is torn, the blood may then find its way into the open end of the bile duct and subsequently pass into the duodenum by way of the common duct. If the bleeding is massive, blood will regurgitate proximally into the stomach as well as pass distally, thereby resulting in hematemesis as well as melena. As the blood passes the opening of the cystic duct, some of it finds its way through the cystic duct into the gallbladder along with bile. A portion of this blood may clot; clots may lodge in the cystic duct from the gallbladder side and

block the exit. Although the marked distention of the gallbladder in the patient herein reported, was presumably caused by hemorrhage in the gallbladder itself, such distention might be produced in case the injury were limited to the liver itself, if the clot in the neck of the gallbladder would result in a ball valve action. This apparently happens, since distended gallbladders have been observed in lacerations of the liver with melena and hematemesis.

The author wishes to re-emphasize the statement of Hermanson and Cabitt<sup>1</sup> that "it does not seem to be a generally appreciated fact that injury to the biliary tract may give rise to hematemesis and melena." Recognition of this fact would avoid the occasional error made diagnostically in traumatic lesions of the biliary tract. The importance of this statement can be appreciated if we consider how much time might be lost and damage done by the surgeon searching for a torn vessel in the wall of the intestine, when, in reality, the bleeding was arising from a laceration in the liver. Since it is necessary for the capsule of the liver to be intact before blood will escape by way of the common duct into the duodenum in large quantities, the surgeon will find no laceration of the liver, but palpation will reveal abnormal consistency or topography of the liver incident to the laceration and blood clots which will accumulate.

Although it is outside the province of this paper to discuss hepatic injury, the above discussion has been included since injury to the liver alone might result in marked distention of the gallbladder with blood and bile, thereby making identification of the active source of bleeding extremely difficult in some cases. Although there was an area of increased consistency in the liver of the patient herein discussed, we scarcely thought it was definite enough to be classed as a significant injury, particularly because we found a possible source of injury in the gallbladder wall and because elimination of distention of the gallbladder by cholecystostomy apparently cured the patient. We realize, of course, that operation may

have had nothing to do with the cessation of bleeding even though it had persisted for six weeks prior to operation.

As far as a perusal of the literature could ascertain, this is the first case in which a nonpenetrating traumatic injury to the gallbladder has produced hematemesis and shock, complicated by a hemorrhagic hydrops of the gallbladder.

#### SUMMARY

A case of injury to the gallbladder resulting in repeated hemorrhages into the intestine by way of the cystic and common duct, with hematemesis, is described. An indurated, ecchymotic area on the superior wall of the ampulla of the gallbladder, which presumably represented the partially healed site of the hemorrhage was found at operation. An indefinite indurated area in the liver adjacent to the gallbladder was found, but from this data the diagnosis of a laceration of the liver with hemorrhage scarcely seemed justified. The fact that cholecystostomy, with relief of distention in the gallbladder resulted in cessation of the hemorrhage, offers additional evidence that the site of the bleeding was in the gallbladder.

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# X-RAY DIAGNOSIS OF EARLY INTESTINAL OBSTRUCTION\*

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INTESTINAL obstruction, once the nightmare of the surgeon, is now a condition that can be detected by the lateral view of the abdomen with the patient lying on the back and the upright view in the anteriorposterior projection.

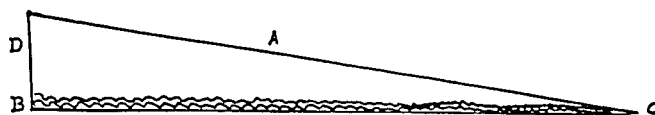


FIG. 1.

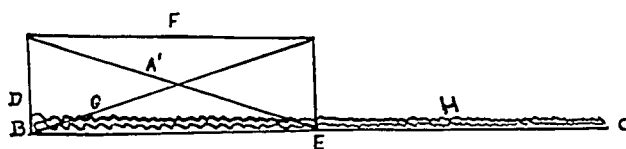


FIG. 2.

FIGS. 1 AND 2. A, normal gradient; B-C, intestinal tract; D, force of peristalsis at the beginning; E, point of obstruction; A', peristalsis in obstruction more forceful; F, reverse peristalsis with equal force; G, reverse peristalsis with lessened force; H, weak peristalsis beyond obstruction.

x-ray before irreparable damage has been done.

The profession is indebted to Schwarz<sup>1</sup> who, in 1911, demonstrated localized gas pockets and fluid levels in coils of the gut and the failure of bismuth to pass beyond a given point. He reported four cases that proved to be intestinal obstruction. The main points in his observations were the gas with fluid level, exaggeration of the Kerkring folds and disturbance of motor function. This work was corroborated by Stierlin<sup>2</sup> in 1913. Kloiber<sup>3</sup> demonstrated that the characteristic x-ray findings are sometimes seen as early as three hours after the onset of symptoms.

The marked similarity of paralytic ileus and mechanical obstruction has caused some confusion in making a differential diagnosis. The cause, x-ray findings, treatment and prognosis are decidedly different. It is the object of this paper to present the differential aspects as determined by

The air pockets and fluid levels are clearly visualized in mechanical obstruction but the latter are absent in paralytic ileus. This important information cannot be obtained from the anterior posterior view while the patient is in the prone position.

In order to explain these differential points it will be necessary to review some phases of the physiology of the gastrointestinal tract, both normal and pathological. The factors in paralytic and mechanical obstruction are the presence of gas and failure of motor function in both, and the presence of fluid levels in the mechanical type.

The anatomical considerations are important because of the bearing on symptomatology and the time of the appearance of fluid and gas in different portions of the intestinal tract. Dragstedt and his associates<sup>4</sup> have demonstrated a much richer blood supply due to the larger size of the vessels in the upper segments of the intes-

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tinal tract as compared with the lower. The vessels decrease in size as the distal end is approached.



FIG. 3. The lateral projection is made with the patient lying on the stretcher. Note the distention of the abdomen, pockets of gas in the coils of gut and numerous fluid levels. These, of course, could not be seen in the anteroposterior view.

Morton<sup>5</sup> states that the secretion of the duodenum is five to ten times that of the ileum in a given period of time. According to Owings<sup>6</sup> the pressure in the intestinal tract under normal conditions is 2 to 5 cm. of water. This has been known to increase to 24 to 36 cm. of water in twenty-four hours in the duodenum and ileum when obstruction is present. The greater the peristalsis the greater the pressure.

Brandes<sup>7</sup> claims that in mechanical obstruction there is great hypertonicity and less absorptive powers. This is another factor causing increased pressure.

Ochsner<sup>8</sup> in his experiments on animals found that in strangulation of the jejunum, positive x-ray evidence occurred in three hours. In simple obstruction of the ileum gas was found in one hour and fluid levels in three hours. In strangulated obstruction of the ileum gas and fluid occurred in one hour.

In summarizing, we have a vicious circle. The higher the obstruction the earlier and more severe the symptoms. The obstruction to the flow of the intestinal contents brings about increased pressure and decrease in the absorptive powers of the gut, increased peristalsis, increased pain and toxicity.

The above condition gives a mark distortion of the gradient. This might be illustrated in Figures 1 and 2.



FIG. 4. The film was made with the patient standing. Note the numerous fluid levels which could not be detected in the anteroposterior view, recumbent position.

#### CASE REPORTS

CASE I. W. J., a female, age seventy-three, had a pulse rate of 120, respirations 45, and temperature 97°F. on admission. She complained of nausea, vomiting and constipation of seven days' duration. She had vomited twelve times on the morning of admission. Her abdomen was distended and painful. X-ray examination in the anteroposterior view, not seen here, showed an enormous amount of gas in the tract. The lateral view showed pockets of gas and numerous fluid levels. (Fig. 3.) This fits the pattern of mechanical obstruction. The patient died without operation. Diagnosis was confirmed at autopsy.

CASE II. P. R., age forty, was admitted with a diagnosis of luetic gastritis. Wassermann and Kahn tests were negative. There were no distention, nausea, or vomiting, but the patient had drawing sensations in the lower right quadrant. The abdomen was tender and slightly distended. The temperature was 98.8°F. pulse 96, respirations 20. X-ray examination in the upright position showed gas and fluid levels. (Fig. 4.) Diagnosis: intestinal obstruction. Operation showed postoperative adhesions

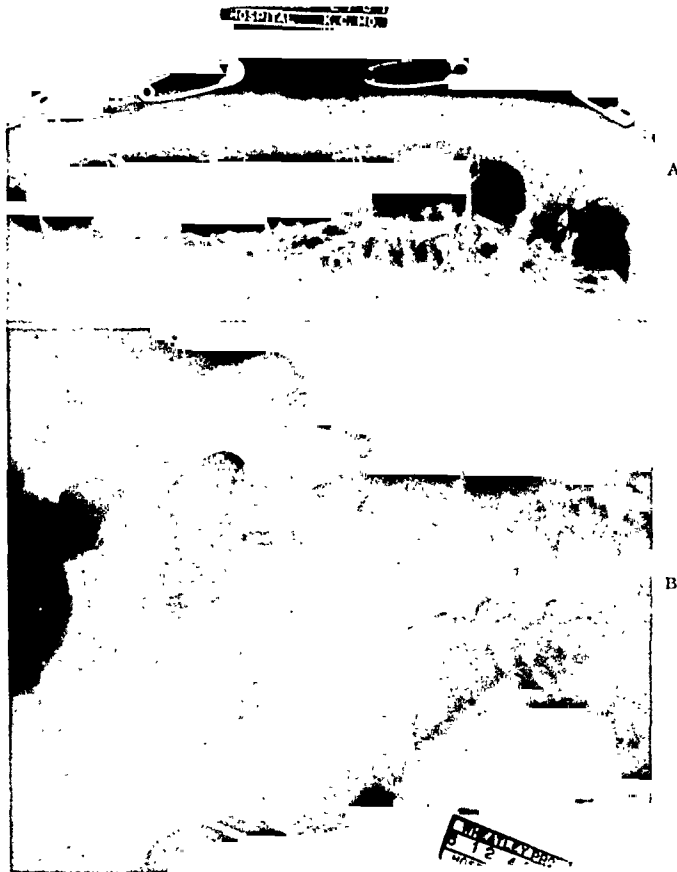


FIG. 5. A, this is the lateral view in the recumbent position. Note the enormous amount of gas in the coils of gut but no fluid levels. This information could not be obtained from the anteroposterior view (B) taken in the prone position.

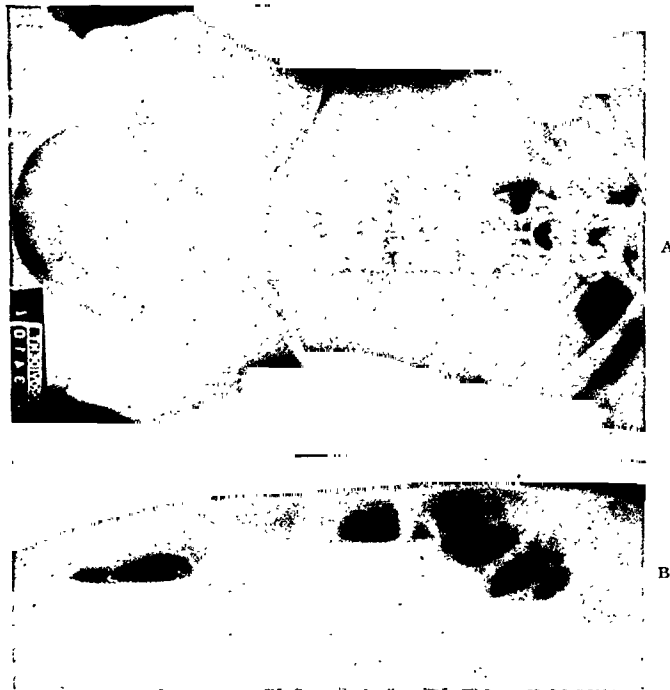


FIG. 6. A, shows an anteroposterior view of the abdomen with the patient in the prone position. B, lateral view with the patient in the prone position.

causing partial obstruction in the hepatic flexure of the colon.

CASE III. L. G., a female, age thirty, was

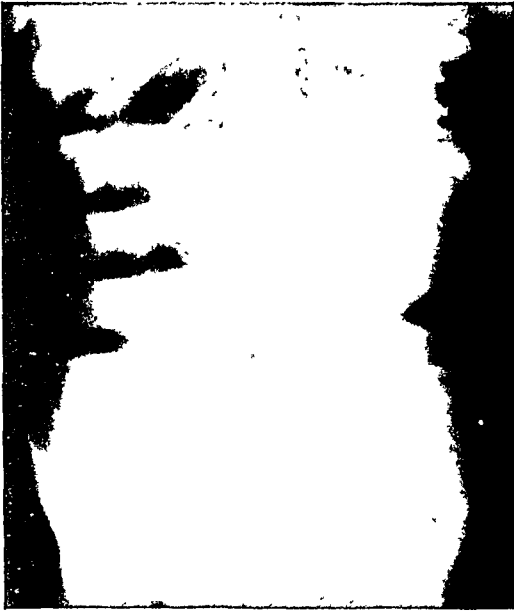


FIG. 6. c, this shows the patient in the upright position.

operated upon June 8, 1940 for appendicitis. On June fifteenth the patient complained of pain in the abdomen and distention was present. X-ray examination showed intestines markedly distended with gas but no fluid levels. (Figs. 5A and B.) Diagnosis: paralytic ileus. The patient was operated upon in about two hours after the x-ray was made. A purulent peritonitis with recent, very soft adhesions were found.

CASE IV. J. C., a male, age nineteen, entered the hospital complaining of sudden pain in the abdomen. He had vomited once, twelve hours after the onset. Figure 6A shows an anteroposterior view of the abdomen with the patient in the prone position. Gas pockets in the dilated gut were prominent. Figure 6B is a lateral view with the patient in the prone position and Figure 6c shows the patient in the upright position. Numerous fluid levels and gas pockets

are noted. They were persistent after the administration of enemas. These films were made twenty-four hours after the illness began. Diagnosis of intestinal obstruction was made on these findings.

The operation showed the ileum bound down by a band of adhesions. It was four inches from the cecum and about one inch in width. The obstruction was not complete. The entire gut above was red but not gangrenous. Numerous bands of adhesions were found around the cecum and lower portion of the ascending colon. Recovery was uneventful.

### CONCLUSIONS

The necessity of upright and lateral views of the abdomen in making a diagnosis of intestinal obstruction is emphasized. Cases are presented showing the differential points between mechanical obstruction and paralytic ileus based on the presence or absence of gas with or without fluid levels.

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# ERRORS IN INTERPRETATION OF REFERRED PAIN OF BONE ORIGIN\*

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MANY errors in diagnosis result from an almost universal tendency to consider the region of pain localization as the seat of the disease. The patient judges the position of his disease by the most prominent, painful symptoms. The physician, however, should not fall into this trap. Failure to elicit local signs of disease, such as redness, tenderness, swelling or increased heat, immediately should suggest the possibility of referred pain.

The reality of referred pain of pleural and peritoneal origin is attested by numerous case reports and by the investigative work of Morley,<sup>1</sup> Capps,<sup>2</sup> McKenzie<sup>3</sup> and Lenander.<sup>4</sup> Kellegren's<sup>5</sup> careful investigations demonstrate conclusively that deep somatic structures such as tendons, bones, muscles and ligaments, give rise to referred pain with a spinal segmental distribution, a fact originally postulated by Hilton<sup>6</sup> following clinical observations.

Hilton (1880) mentioned that "sympathetic" pain in the knee as a result of disease of the hip joint commonly was recognized before his day. He cited pain in the forearm arising from disease of the shoulder joint, and abdominal and thoracic pain associated with disease of the vertebrae. Bruce<sup>7</sup> (1904) wrote at length on the subject "Referred Pains of Gouty Origin" and quoted Hilton freely. He, too, mentioned pain and tingling in the forearms associated with inflammation of the shoulder joint, and pain in the limbs in affection of the articulating surfaces of the vertebrae. Upson and Nielson<sup>8</sup> (1928) presented roentgenograms of the spine and correlated the pathological findings with referred pain and muscular atrophy. Wagner<sup>9</sup> (1935) re-

ported a series of twelve congenital defects of the lumbosacral joints associated with nerve symptoms. Neither Wagner nor



FIG. 1. Chondrosarcoma (A) that gave rise to referred pain localized in the arch of the right foot. Lesion was overlooked for two years.

Upson and Nielson differentiated between pain arising as a result of bone pressing on a nerve, as in a gibbus or spondylolisthesis, and referred pain of bone origin although some of their cases belonged in the latter classification. Schnaberth<sup>10</sup> (1939) reported a case with indefinite pain in the right hip for years as the only symptom of tuberculous spondylitis of the fourth and fifth vertebrae. He stated that he, like several other consultants, had considered the man a malingerer for several years until the true cause of his pain was discovered by accident, roentgenologically.

The following case reports further attest the failure of the profession to appreciate

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the reality of referred pain of bone origin. All had been diagnosed incorrectly one or more times. With few exceptions the under-

Roentgenograms of the ankle and knee showed no pathological state. Repeated examinations by various physicians failed to reveal a cause



FIG. 2. Round cell sarcoma (A) of the left sacro-iliac joint overlooked for eighteen months. It had given rise to referred pain localized in the left ankle.

lying cause remained undiscovered until definite, localizing, objective findings developed. In several patients needless operations were performed in the region of pain localization.

#### CASE REPORTS

**CASE I.** E. K., a white female, thirty-nine years old, suffered for two years with constant, severe pain in the arch of her right foot. Despite repeated examinations and treatment, no cause for the pain was demonstrated and no relief experienced. Gradually the pain spread up her leg. Attention was drawn to the hip only after the thigh had become swollen. Roentgenograms of the ankle revealed no disease; those of the hip showed a destructive lesion involving the intertrochanteric region of the femur. (Fig. 1.) An operation was performed and a blue-gray cartilaginous tumor removed. Following operation the pain disappeared. The histological report was of chondrosarcoma. Within the year the tumor recurred, as did the pain, and the patient died with metastasis.

**CASE II.** F. R., a white female, age twenty-four years, for eighteen months had constant ankle pain with occasional exacerbations, during which the pain spread to the calf and thigh.

for pain. The pain finally spread over the entire leg. Roentgenograms of the pelvis showed a destructive lesion involving the left sacroiliac joint. (Fig. 2.) A biopsy was performed and examination of the removed tissue revealed it to be a round cell sarcoma. Irradiation of this tumor resulted in temporary relief from pain. The tumor recurred, as did the pain, and the patient died with metastasis.

**CASE III.** R. J., a white female, twenty-one years old, complained of pain in her right knee of eleven months' duration. The pain appeared shortly after an automobile accident, which was thought by the patient to be the cause of the onset of symptoms. There were never any local findings such as swelling, redness or tenderness. The pain was well localized to the skin overlying the region of the internal semilunar cartilage. Roentgenograms were taken. Orthopedic consultants considered the symptoms to be the result of a torn internal semilunar cartilage, as that was where the pain localized. An operation was performed and the internal cartilage removed, but the patient experienced no relief. A third surgeon advised removal of the lesion on the shaft of the femur. (Fig. 3.) Microscopic sections showed it to be a chronic, fibrous osteomyelitis. Complete relief from pain followed the operation.

CASE IV. J. D., a white male, sixteen years old, first noticed pain in his right knee. The pain appeared without apparent cause and gradually

disease in the knee or hip joints, but found the thigh enlarged, warm and tender. Roentgenograms of the femur revealed an osteomyelitis.



FIG. 3. Chronic fibrous osteomyelitis (A) that caused referred pain in the region of the internal semilunar cartilage. The cartilage was removed without relief of symptoms.

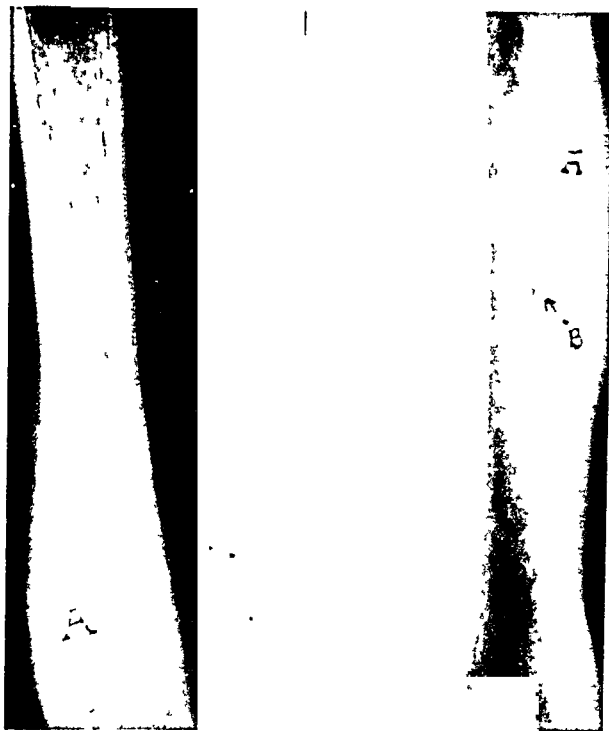


FIG. 4. Osteoid osteoma (B) and periosteal reaction (A) in the middle of the femoral shaft that caused referred pain in the region of the knee joint and upper tibia.

increased until it was present day and night and was severe enough to keep him awake. Although roentgenograms of the knee were negative, the leg was placed in a cast for three weeks. The pain persisted. The patient was referred, therefore, to an orthopedic surgeon who found nothing wrong with knee or hip joint and advised rest. One month later, because of continued pain, the patient consulted a second orthopedic surgeon who also found no pathologic condition. A third consultant found the knee and hip joints normal but on deep palpation of the thigh detected an enlargement of the shaft of the femur. Roentgenograms of this region revealed an osteoid osteoma. (Fig. 4.) Removal of the lesion gave complete relief.

CASE V. R. O., a white male, forty-one years old, complained of pain in the right knee of three months' duration. The pain increased in severity and kept him awake at night. Two physicians found nothing wrong with the knee clinically or roentgenologically. At their suggestion three teeth and his tonsils were removed, without relief. A third consultant found no

(Fig. 5.) Incision and drainage were followed by complete relief from pain.

CASE VI. P. B., a white female, age seven years, complained of pain in the lateral side of her thigh near the knee. Clinically, she presented the typical picture of an acute osteomyelitis of the femur and her pediatrician referred her to a surgeon, who found no disease in the femur. However, he did find tenderness in the ilium in the region of the acetabulum. The pediatrician, positive the femur was involved because the pain was limited to the thigh, insisted that the consultant surgeon first aspirate the tender region. Pus was obtained and an operation was performed revealing an acute osteomyelitis of the acetabulum. (Fig. 6.) Drainage of this lesion was followed by relief of pain in the thigh.

CASE VII. N. K., a white female, ten years old, after a fall, complained of pain in the mesial, distal portion of her left thigh. Associated with this was a temperature of 103°F., chills and a leucocytosis of 20,000. Roentgenograms of the femur were negative. A pediatrician diagnosed osteomyelitis of the femur and advised hospitalization. A consultant surgeon

concurrent in the diagnosis, and advised incision and drainage of the shaft of the femur. A second surgeon was consulted. He elicited no tender-

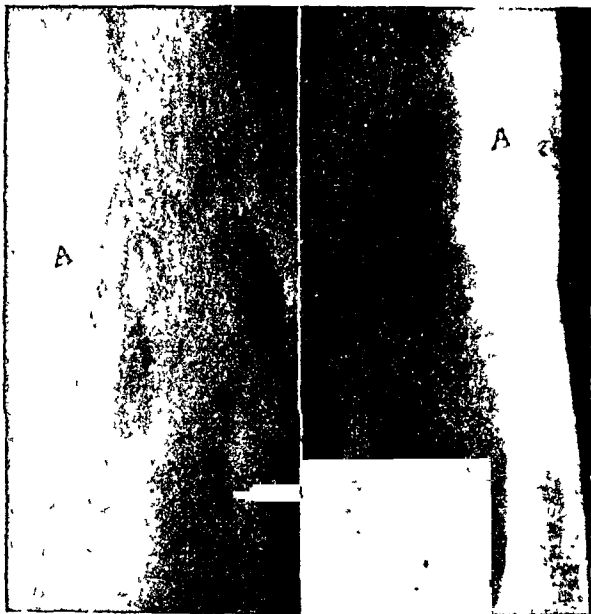


FIG. 5. Postoperative anteroposterior and lateral views of sclerosing type of osteomyelitis of the shaft that gave rise to referred pain in the knee joint. A, periosteal reaction; B, operative defect.

ness in the femur but found tenderness upon rectal examination and noticed slight swelling of the vulva of the same side. Roentgenograms

osteomyelitis of the interior ramus of the left pubis. (Fig. 7.) Relief from pain followed incision and drainage of the pubic lesion.

CASE VIII. R. C., a white male, ten years of age, who previously had been operated upon because of recurrent osteomyelitis, complained of pain in the epitrochlear region of the left humerus. There was an associated low grade fever and leucocytosis. Local findings were not significant and roentgenograms of the elbow were negative. Because motion of the elbow increased the pain, the elbow joint was opened but no pus was found. The operation did not relieve the pain and the temperature remained elevated. The patient was discharged from the hospital five days after drainage of the elbow joint. The pain increased gradually and spread up the arm as far as the deltoid region; three days later he was hospitalized. Examination of the deltoid region revealed increased heat, tenderness and swelling of the upper shaft of the humerus. Roentgenograms showed a frank osteomyelitis. Incision and drainage of a large quantity of pus from this region was followed by complete relief of pain and a return of the temperature to normal.

CASE IX. H. N., a white male, ten years old, stumbled and fell on his right arm. As he immediately complained of pain in his right elbow, his mother took him to an orthopedic surgeon



FIG. 6. Location of the focus of osteomyelitis (A) that gave rise to referred pain in the lateral portion of the thigh. This is a picture taken five years after onset and shows much more involvement than was originally present.

of the pelvis showed no changes. He suggested that operation be delayed. Roentgenograms of the pelvis fourteen days later revealed an

Examination revealed some slight tenderness in the elbow, no swelling and a full range of motion in the elbow and shoulder joints.



FIG. 7. Osteomyelitis of the inferior ramus of the left pubic bone that caused referred pain in the distal portion of the left thigh.



FIG. 8. Focus of osteomyelitis (A) of the upper humerus that caused referred pain in the elbow for which an arthrotomy of the elbow had been performed.



FIG. 9. Comminuted fracture of the upper humerus that gave rise to referred pain in the elbow region.

Roentgenograms of the elbow joint were negative and the patient was sent home with the arm in a sling. Four days later he returned. Immobilization had given no relief; instead, the pain had grown worse and had spread up his arm. Roentgenograms of the entire humerus (Fig. 9) revealed an impacted fracture of the neck. Immobilization in a Valpeau bandage with plaster to stabilize it gave complete relief from pain.

Cutaneous pains are projected under normal conditions with great accuracy to the joint stimulated. Pains arising in deep somatic structures and viscera, on the contrary, are indefinitely localized and often may be referred to points on the skin remote from the origin of stimulation. The cases reported in this paper as well as the more generally known examples of stones in the cystic duct or ureter giving rise to pain in the region of the scapula and scrotum, respectively; disease of the hip joint causing pain in the knee; pain arising in the dome of the diaphragm, referred to the shoulder and neck, illustrate how faulty the location of disease by pain may be. The clinical and investigative evidence that slowly is accumulating substantiates the opinion that the different visceral and deep-lying somatic structures have a definite, spinal, segmental relation to the skin. Appreciation of this fact, particularly when pain localized to a region in which there are no objective findings is concerned, will eliminate errors in diagnosis. Emphasis should be on the fact that roentgenographic examination should not be limited to the region of pain localization, but should include areas that might give rise to referred pain to this region.

#### SUMMARY

1. Nine cases of referred pain of bone origin are reported.
2. All had been diagnosed incorrectly

one or more times because the region of pain localization had been considered the seat of the disease.

3. Two patients had been operated upon unnecessarily in the region of pain localization.

#### CONCLUSION

Disease of bone may give rise to referred pain in regions so far removed from the diseased area that roentgenograms limited to the area of pain localization fail to demonstrate the lesion.

Referred pain is undoubtedly more common than is generally appreciated. In the absence of objective findings in the region of pain localization, a thorough search of all deeper somatic and visceral structures that might cause referred pain of the segmental pattern under question will eliminate many mistakes.

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# THE VALUE OF THE FRACTIONAL HORMONAL TESTS IN THE DIAGNOSIS OF HYDATIDIFORM MOLES\*

## REPORT OF TWO CASES

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### INTRODUCTION

**H**YDATIDIFORM mole is not a rare disease of the placenta. The authors wish to bring before general surgeons the records of two patients who were recently admitted to a 100-bed rural hospital and to emphasize the value of the fractional hormonal tests as an aid in the diagnosis of this disease.

Probably the greatest modern advance in the study of hydatidiform mole was the development in 1929 of the fractional Aschheim-Zondek test<sup>1,2</sup> and the discovery<sup>1</sup> that the excretion of gonadotrophic hormone in the urine of cases of mole was two to three times as great as is found in the urine of normally pregnant women. This sensitive response with small amounts of urine was at first thought to be pathognomonic of a mole, but positive tests in relatively high dilutions were later noted in the presence of toxemias of pregnancy. Mathieu<sup>3,4</sup> believes that the drop in the general mortality in this disease from 12 per cent to 2 per cent in the past ten years may be attributed largely to the use of hormonal diagnostic aids.

The authors believe that the fractional hormonal test probably is more helpful in the preoperative diagnosis of a mole than the usual clinical findings. The smallest amount of urine which gave a positive *Friedman test* in cases of hydatidiform mole was reported by Shoeneck<sup>7</sup> to be .0065 cc. Toxemias of pregnancy have given positive *Friedman tests* in as small as .001 cc. of urine. The urine of normally pregnant women rarely gives a positive response in a greater fraction than .05 cc.<sup>7</sup> of the specimen.

The *Aschheim-Zondek test* requires the

injection of 2.4 cc. of undiluted urine for the usual pregnancy-test. The urine of normally pregnant women has given a positive response in amounts as small as 2.4 cc. of a  $\frac{1}{50}$  solution in distilled water. Dilutions from  $\frac{1}{50}$  to  $\frac{1}{150}$  suggest the presence of a mole, and dilutions above this level indicate the presence of a chorio-epithelioma.<sup>8</sup>

For many reasons the *Friedman modification*<sup>5</sup> of the *Aschheim-Zondek test* has been more widely used in America: (1) A definite result can be obtained in forty-eight hours; (2) the rabbit may be used repeatedly; (3) it has not been found practical to keep colonies of mice of six to eight weeks of age. In both tests, however, the results depend upon the presence in the urine of an increased amount of anterior pituitary-like hormone, and the significance of positive tests in higher dilutions with either method is identical.

Hydatidiform moles are estimated to occur once in two thousand deliveries. Recently Mathieu<sup>3,4</sup> stated that they were probably more frequent than this and quoted a figure of one in six hundred private deliveries. The two cases presented in this paper, together with one earlier case found in the files of the hospital, represent an incidence of approximately one in four hundred deliveries.

### CASE REPORTS

**CASE 1.** Mrs. A. D., a twenty year old married American housewife, para 0, gravida 1, was admitted to the surgical service January 28, 1940 with a chief complaint of vaginal bleeding of five weeks' duration.

Her father had suffered from diabetes and Bright's disease; otherwise her past history and family history were irrelevant.

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The patient had had her last normal menstrual period during the third week of October, 1939. About November 1 she experienced some morning nausea and persistent vomiting, which continued until her entrance and was the most probable cause for her twenty-five-pound weight loss. There were no headaches or urinary symptoms during this period.

On December 23 (approximately five weeks before admission) she noticed the onset of dark brown vaginal discharge which required the use of two or three perineal pads daily. Anorexia, nausea, vomiting and marked fatigue, together with frequency of urination were daily symptoms.

On admission her temperature was 99.4°F. by rectum, the pulse rate was 94 per minute, her respirations 18, and the blood pressure 150/90. She appeared to be a pale, thin, undernourished girl. Her fundi were normal. The heart was of normal size and presented no murmurs. Her breasts were full but there was little areolar pigmentation. In the midline of the abdomen a soft, compressible, symmetrical tumor arose from the pelvis and extended to just below the umbilicus. A loud souffle could be heard over the entire lower portion of the mass by auscultation. There was some deep tenderness in the right lower quadrant by palpation, but otherwise the abdominal examination was negative. Her cervix was found to be soft, smooth, and cyanotic and her uterus was soft and almost filled the pelvis. The reflexes were physiological.

*Laboratory and Roentgenological Examinations.* *Biological Pregnancy Tests:* The Friedman test was positive with 20 cc., with .025 cc. and with .001 cc., of urine on January 29, 1940, January 29, 1940, and February 1, 1940, respectively.

The hemoglobin was 66 per cent, the red blood cells were 3,250,000 and the white blood cells 8,600 with 70 per cent polymorphonuclears. The icteric index was 10 and the non-protein nitrogen was 62 mg. per cent. The serum proteins were 4.11 mg. per cent with 2.33 mg. per cent albumin and 1.78 mg. per cent globulin. The albumin-globulin ratio was 1:1:31.

Upon examination of the urine (catheterized specimen) the reaction was acid and the specific gravity 1.022. There was no sugar in the specimen but the albumin test was strongly positive (4 plus). There were occasional red cells in

the smear but no casts. The culture yielded a few colonies of *Staphylococcus aureus*.

The vaginal cultures were not impressive. Only a Gram-negative bacillus grew out on the plate cultured in the anaerobic jar.

*Clinical Course.* The vaginal bleeding and vomiting ceased after four days of bed-rest. Her general condition continued to improve. The presence of positive Friedman tests in high dilutions of urine made the diagnosis of hydatidiform mole a strong possibility.

On February 14, 1940 the patient was taken to the operating room and under gas, oxygen and ether anesthesia a dilatation of her cervix was performed. A finger was then introduced into the uterus and immediately contacted a soft, jelly-like mass, small amounts of which were removed with sponge forceps. Grossly, the specimens (connected) resembled particles of tapioca connected by a thin greyish-white network of fibers. Subsequent profuse bleeding forced the operator to pack the uterus.

On the second postoperative day the packing was removed. Cultures of the vagina at this time were negative both aerobically and anaerobically. On the third postoperative day she expelled a large mass of tissue weighing over 500 Gm. and thereafter continued to pass small amounts of the mole for the next five days.

On the ninth postoperative day the uterus was completely emptied by curettage under spinal anesthesia. A large amount of necrotic decidua-like tissue was obtained.

Three weeks after her discharge a Friedman test was negative with 20 cc. of urine. The patient was enjoying excellent health and was having what appeared to be a normal menstrual period.

*Pathology Report—First Curettage.* "Four sections of the tissue were examined microscopically. In these sections blood clots, fibrous tissue, strands of decidua, and typical chorionic villi were found. The latter were most interesting and are surrounded by a loose connective tissue stroma resembling Wharton's jelly. The periphery of the villi are lined by 1 to 4 layers of Langhans cells and an increased number of syncytial cells. In many areas they form small buds in the outer lining of the villi. A few appear normal. Some villi appear edematous while a few others appear to have undergone mucoid degeneration. Necrosis of decidua and villous tissue is present. One section contains a

small area of the inflammatory exudate. In section #4641 the proliferation of the lining cells of the villi is more prominent."

*Second Curettage.* "The sections of curettings #1 reveal a heterogeneous mass of tissue in which are found uterine mucosa, myometrium, degenerating decidua, organized blood clot, inflammatory exudate, a few Langhans cells and a few syncytial cells. No villi were present."

#### DISCUSSION

On history and physical examination the patient exhibited many of the typical signs of the disease. The onset occurred during the first trimester of pregnancy and was characterized by vaginal bleeding. Ninety per cent of the patients in various series entered with vaginal bleeding as a presenting symptom. Associated toxemias are reported as complications of pregnancy in 29 to 35 per cent of these cases.<sup>6</sup> This patient's breasts oddly enough lacked the usual development associated with the pregnant state. Although she had missed only three menstrual periods, her uterus was consistent with the size of a five-months pregnancy. Mathieu<sup>3</sup> states that only 50 per cent of hydatidiform moles manifest an abnormal enlargement of the uterus. The positive ovarian response in the rabbit (Friedman) test with dilutions of urine as high as .025 cc. and .001 cc. was largely responsible for the correct preoperative diagnosis.

**CASE 11.** Miss D. S., a twenty-six year old single, American white girl, was admitted to the surgical service on May 18, 1941 with a complaint of bloody vaginal discharge of two and a half months' duration.

Her father had had diabetes, but otherwise the past and family history were negative.

On February 27, about two and a half months before, she began to have a bloody vaginal discharge. Menstruation had been regular until her last period, which occurred on January 15, 1941. She spotted slightly on February 27 and since that time had had "slight spotting" daily. She had had some slight nausea and vomiting during the first month, but otherwise had felt fairly well; no fetal movements were noted. She had not lost

any weight and had had on headache or excessive fatigue.

On admission her temperature was 98.4°F., her pulse 78, respirations 18, and blood pressure 160/86. She was slightly pale and thin, her eye grounds were normal, and her throat slightly injected. The heart seemed of normal size without significant murmurs. The lungs were clear. The breasts were small with the left nipple flat and the right one inverted. On abdominal examination there was a rather firm symmetrical mass rising out of the pelvis to within one finger-breadth of the umbilicus. It was non-tender and there were no other masses felt. On pelvic examination the outlet was marital, and the cervix was soft, smooth and large. There was a small amount of blood in the posterior vaginal fornix. The previously described abdominal mass was apparently uterus.

*Laboratory Examinations. Biological Pregnancy Tests:* Aschheim-Zondek test (a) 2.4 cc. without dilution was positive; (b) 2.4 cc. with  $\frac{1}{50}$  dilution was positive; (c) 2.4 cc. with  $\frac{1}{100}$  dilution was positive; (d) 2.4 cc. with  $\frac{1}{150}$  dilution was positive; (e) 2.4 cc. with  $\frac{1}{200}$  dilution was positive. Friedman test was negative with dilutions of .025 cc., .005 cc., and .001 cc. of urine.

The hemoglobin was 71 per cent. The red blood cell count was 4,350,000 and the leucocytic count 11,600, with 62 per cent polymorphonuclears.

The cell volume was 43.2 per cent and the sedimentation rate .50 mg. per hour. The non-protein nitrogen values were reported as 18 mg. per cent, the urine acid as 3.9 mg. per cent. The serum protein amounted to 6.23 mg. per cent with the serum albumin accounting for 3.01 mg. per cent. The phenolsulfonphthalein test showed values of 60 per cent for the first hour and 8 per cent for the second hour.

The specific gravity of urine was 1.010 and the reaction acid. There was no albumin or sugar found in the specimen. On microscopic examination three to four red blood cells and a few white blood cells per high powered field were detected. The culture yielded no growth in forty-eight hours.

*Clinical Course.* The patient was discharged from the hospital after a short work-up because at the time of her discharge we were not certain that she had a mole, for the fractional Aschheim-Zondek test had not been returned. When this was positive in high dilutions, we strongly



suspected the presence of a mole. She was, therefore, readmitted to the hospital on June 2, 1941 and after donors had been procured was operated upon the next morning.

At this time a typical hydatidiform mole was removed from her uterus with average difficulty, and with considerable bleeding. She required a transfusion after the procedure was completed, but otherwise went on to a very satisfactory immediate convalescence. Her blood pressure returned to normal limits (systolic 125, diastolic 75) and her hemoglobin was 88 per cent on discharge. Her slides were reviewed by Dr. A. T. Hertig of the Lying-In Hospital, Boston, who thought the mole tissue had malignant tendencies but that she should be followed conservatively for a period of a few months.

#### DISCUSSION

This case history is not as yet complete. It is presented, however, to indicate the value of the fractional hormonal tests in the diagnosis of this uncommon tumor. For academic reasons both the Friedman and Aschheim-Zondek tests were employed. The Friedman tests were done with very high dilutions of urine in order to determine as accurately as possible the exact concentration of gonadotrophic hormone present. Unfortunately, the dilutions used did not

produce any ovarian response in the rabbits. The dilutions employed in the Aschheim-Zondek tests were between two and three times greater than the smallest amounts which could be expected to produce a response in the normal pregnant state. Dilutions of  $\frac{1}{50}$ ,  $\frac{1}{100}$ ,  $\frac{1}{150}$  and  $\frac{1}{200}$  were strongly positive and indicated the correct diagnosis of mole.<sup>8</sup>

#### SUMMARY

Two cases of hydatidiform mole admitted to a rural (100-bed) hospital within two years are reported.

In both cases fractional hormonal tests were found to be positive in high dilutions and led to the correct preoperative diagnosis.

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# LARGE PEDUNCULATED CAVERNOUS HEMANGIOMA OF THE LIVER

## CASE REPORT

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WHILE cavernous angiomas are reported to be the commonest benign tumor of the liver they are usually multiple, of small size and fail to produce

developed eight years previously, necessitating retirement from teaching, but was never definitely diagnosed and showed no improvement until a few months prior to this admission.

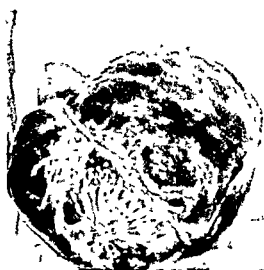


FIG. 1. Photograph of intact gross specimen.



FIG. 2. Photograph of sectioned gross specimen.

symptoms.<sup>7</sup> They are usually found at postmortem examinations.<sup>8</sup> The larger tumors become evident when they can be palpated or produce pressure symptoms. Because of their location and their rarity they have been erroneously diagnosed carcinoma of the stomach,<sup>7</sup> metastatic lesion of the liver,<sup>4</sup> pancreatic cyst<sup>5</sup> and pedunculated myoma of the uterus.<sup>2</sup> The incidence of large pedunculated hemangioma of the liver seems sufficiently rare<sup>4,6</sup> to warrant the following report:

### CASE REPORT

Miss L. J., age sixty years, a retired school teacher, presented herself in April, 1940, because of an epigastric mass which she had first noticed about six weeks previously. The mass was thought to have grown quite rapidly during this period. The only other symptoms were a throbbing sensation intermittently in the epigastrium, especially when lying down and a soreness in this area when stooping or when turning in bed.

The family history was essentially negative. Her past history revealed an aphonia which

The patient appeared about stated age without apparent evidence of ill health. Her temperature was normal, pulse 92 and blood pressure 148/90. General physical examination was negative except for the positive findings in the upper portion of the abdomen. Here a large mass was felt which extended about five fingers' breadth below the tip of the ensiform in the midline and its lower margin extended almost the width of the abdomen. It was slightly movable, moved with respirations and seemed moderately tender. The pulsations of the aorta could be felt and a bruit could be heard but the tumor did not seem to have expansile pulsations. The liver margins were within normal limit and the lower margin did not seem to be contiguous with the mass. The spleen was not palpable.

Urinalysis revealed a trace of albumin and no other abnormal findings. White blood count was 8,100 with a normal differential count. The red blood count was 4,630,000 and the hemoglobin was 8.6 Gm. per cent. The sedimentation rate was 8 mm. in one hour and the Wassermann reaction of the blood was negative.

Fluoroscopic and radiographic x-ray examination of the stomach showed an extrinsic mass

along the lesser curvature which pushed the stomach downward and to the left. Intravenous urography showed a normal urinary

peritoneal space. It lay very firmly against the undersurface of the liver, pushing the gall-bladder and bile ducts down and to the right. The stomach was pushed downward and to the left. The left anterior margin of the right lobe of the liver was quite fibrotic and contained numerous dark nodules.

Abdominal exploration was otherwise negative except for small pedunculated fibroids attached to an atrophic uterus.

A biopsy specimen was removed from the involved area of the liver. The tumor was removed intact with considerable difficulty. Its main point of attachment and source of blood supply seemed to be the gastrohepatic omentum very close to the undersurface of the liver. The postoperative course was uneventful and the patient has remained symptom free to date.

The removed tumor measured 20 by 15 by 10 cm. It was described by the pathologist as dark red in color and of soft cystic consistency. (Fig. 1.) On section it was found to consist of very soft pulp which exuded large quantities of blood. (Fig. 2.) The microscopic description and diagnosis was that of a cavernous hemangioma. (Fig. 3.) The finding of a few scattered cords of normal liver cells led to the conclusion that the tumor had originated in the liver and with growth had become pedunculated into the lesser peritoneal space. (Figs. 4 and 5.)

Microscopic study of the biopsy specimen from the liver revealed an admixture of liver cells, fibrous tissue and hemangiomatous tumor identical in character with sections from certain areas of the tumor.

#### COMMENT

The case here reported had many features in common with other cases which have been reported.<sup>2,4,5,6</sup> In none of these cases was an accurate preoperative diagnosis made.

Hemangionas are considered to be a true neoplastic process of congenital origin.<sup>8</sup> They usually pursue a benign course and grow slowly to adult life. They tend to cease growth with full body development but in many cases the tumor does not become manifest until adult life when they suddenly begin to enlarge. These tumors enlarge and develop by extending solid buds of endothelium into adjacent tissues.



FIG. 3. Photomicrograph of tumor showing hemangiomatous tissue (low power).

FIG. 4. Photomicrograph showing liver cells in an area of the tumor (low power).

FIG. 5. Photomicrograph showing liver cells mixed with fibrous tissue (high power).

tract except for a congenital anomaly on the right side consisting of a bipid type of kidney pelvis and incomplete duplication of the right ureter.

A preoperative diagnosis of pancreatic cyst or pseudopancreatic cyst was made and the abdomen explored through an upper right paramedian incision. A large dark colored multilocular tumor bulged from the lesser

These solid cords of endothelial tissue then become canalized and establish communication with the parent vessel. The cavernous type of hemangioma has no anastomatic connection with surrounding vessels and possesses only one afferent and one efferent vessel. The latter fact is of great importance in the treatment of these tumors.

While hemangiomas are considered benign tumors, a rare metastasizing form with microscopically benign secondary lesions has been reported.<sup>8</sup> Hemangio-endothelioma of the liver has also been reported.<sup>3</sup> It differs from cavernous hemangioma in that the vessels remain in the earlier stages of development, are imperfectly differentiated and blood does not circulate through them. They are composed entirely of endothelial cells, are true endotheliomas and many of these in internal organs exhibit malignant features.<sup>1</sup>

#### SUMMARY

A case of a large pedunculated cavernous hemangioma of the liver successfully removed at operation is presented.

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# PRIMARY IDIOPATHIC SEGMENTAL INFARCTION OF THE GREATER OMENTUM\*

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THE purpose of this paper is to call attention to an apparently rare pathological entity of surgical significance, the etiology and pathogenesis of which is obscure. The author's personal experience with primary segmental infarction of the greater omentum is limited to two cases, herein reported.

In a study of the recent literature the only report of similar cases found was the paper by Pines and Rabinovitch. Hines reported a case of hemorrhagic infarction of the greater omentum in which death occurred. In this instance, however, the greater part of the omentum was involved and the infarct was secondary to portal vein thrombosis.

Berger reported a case in which a large branch of the left gastro-epiploic vein was completely occluded by a thrombus not associated with venous thrombosis elsewhere in the abdomen or torsion of the omentum. Cardiac insufficiency, however, was present and apparently the predisposing factor.

## CASE REPORTS

**CASE I.** A male caucasian, hotel clerk, age, twenty-seven years, was admitted to the hospital August 25, 1936. His chief complaint was abdominal pain of three and one-half days' duration. At the onset gripping abdominal pain occurred intermittently at intervals of approximately an hour and lasted for several minutes as sharp right lower quadrant pain starting at the umbilicus and radiating to the right antero-superior iliac spine. He worked the day of onset of pain and rested in bed the following day, but worked the day preceding his entrance to the hospital. Admission to the hospital was sought because of persisting pain. Between attacks of

sharp pain there persisted a dull aching in the right lower quadrant which was accentuated by eating.

He had had the usual childhood diseases but no surgical procedure was ever necessary.

Physical examination revealed a fairly well developed and nourished white male of twenty-seven years, in no apparent distress. His temperature was 98°F.; pulse 58; respiration, 22. General physical examination was negative. Musculature of the abdomen was good; there were no scars and no abnormal masses or palpable organs. Tenderness in right lower quadrant was 3 plus; rigidity in right lower quadrant, 1 plus but no costovertebral angle tenderness. The prostate was slightly tender, but there were no masses nor other tenderness.

Urine and blood Wassermann reactions were negative. Both kidneys appeared normal in size, shape and position and no urinary calculi were observed.

Preoperative diagnosis: Acute appendicitis.

Thorough exploration of the abdomen, including inspection of the lesser peritoneal cavity through an incision in the gastrocolic omentum, revealed no abnormalities except necrosis and hemorrhagic extravasation of the omentum at the distal free border which included an area approximately 6 by 2 cm. The appendix appeared to be only mildly injected on its serosal surface and was otherwise normal.

Ether by the open drop method was given and a right rectus incision made. Resection of the area of necrotic omental tissue and appendectomy were performed. Closure in layers without drainage was carried out. The patient had an uneventful convalescence and was discharged on the tenth postoperative day.

Postoperative diagnosis: Hemorrhagic infarct of omentum.

*Pathological Report.* The mass of omental tissue measured 6 by 2 cm. On section areas showed a considerable amount of bloody infiltration into the fatty tissue, the latter form-

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ing a fairly firm structure through the center of which coursed a vessel occluded by a thrombus.

The microscopic examination revealed omen-

There was tenderness in the epigastrium and right para-umbilical region with maximum intensity in the latter area and moderate right



FIG. 1. Case I. Photomicrograph showing omental vessel in infarcted area occluded by a thrombus.



FIG. 2. Case II. Photomicrograph showing infiltration of extravasated blood into omental fat.

tal tissue infiltrated with round cells and extravasated blood, containing thin-walled blood vessels filled with thrombi.

**CASE II.** E. L., a white male, age twenty-nine years, was admitted to the hospital on December 3, 1940. His chief complaint was burning pain in the epigastrium and anorexia. Onset had occurred forty-eight hours before admission. The burning sensation had gradually developed into a burning pain which several hours after onset shifted from the epigastrium to the area immediately to the right of the umbilicus. There had been no nausea or vomiting. "Indigestion" had been present over an extended period of time. Eleven years previously he had developed an acute rheumatic endocarditis with aortic insufficiency which was adequately compensated at the present time.

His temperature was 100.8°F., pulse 104, respirations 22, red blood cells, 5,280,000, hemoglobin 96 per cent, white blood cells 15,500, polymorphonuclear leukocytes, 65 per cent, blood pressure, 170/0. There were visible pulsations of the arteries of the neck and a Corrigan pulse. Examination of the heart revealed the apex of the heart to be two fingers' breadth outside the midclavicular line. The diastolic murmur was transmitted down the sternum toward the left, but there was no evidence of cardiac embarrassment or insufficiency.

upper rectus rigidity. There were no masses and peristalsis was diminished. Claybrook's sign was positive. Direct, referred, rebound and referred rebound tenderness was present.

*Impression.* Subacute perforation of peptic ulcer or acute appendicitis with perforation and local peritonitis; old rheumatic heart disease compensated.

At operation there was a large hemorrhagic area in the dependent free edge of the omentum, dark red to purplish in color which felt firm and rather hard. There was no evidence of torsion of the omentum or inflammation or other disease of the adjacent organs. The involved area measured approximately 7 by 4 cm. The parietal and visceral peritoneum appeared somewhat edematous and there was an appreciable amount of clear, free peritoneal fluid. The appendix was short and somewhat thick and the serosa slightly injected.

Cyclopropane was administered and a right rectus incision made. A thorough exploration of the peritoneal cavity was done, the infarcted area of the omentum was resected and appendectomy performed. Closure in layers without drainage completed the operation.

*Postoperative diagnosis:* Hemorrhagic infarction of the omentum.

*Pathological Report.* An irregularly-shaped nodular mass, blackish grey in color, consisted largely of blood clot. On section it was evident

that a hemorrhagic infarct had taken place. Sections of the omental mass showed it to consist largely of blood clot supported by the stroma and a reticular set-up of omental fat. Certain areas showed some tendency toward necrosis due to pressure of the blood clot and lack of an active nutritive blood supply.

*Diagnosis:* Infarct of omentum.

The patient's temperature ranged from 101.6°F. to normal on the fourth postoperative day. His convalescence was uneventful except for slight superficial wound infection.

#### COMMENT

The greater omentum is usually thin, presents a cribriform appearance and always contains some adipose tissue. Between its two anterior layers a short distance from the greater curvature of the stomach is the anastomosis between the right and left gastro-epiploic vessels.

The right gastro-epiploic artery is a terminal branch of the gastroduodenal and anastomoses with the left gastro-epiploic branch of the lineal artery. The left gastro-epiploic vein which receives branches from the anterosuperior and postero-inferior surfaces of the stomach and from the greater omentum ends in the commencement of the lineal vein. The right gastro-epiploic vein is a tributary to the superior mesenteric vein and receives branches from the lower parts of the anterosuperior and postero-inferior surfaces of the stomach and from the greater omentum.

Variations in the size, thickness, amount of adipose tissue and location of omentum are considerable and are probably important in the etiology and symptomatology of this condition.

Lesions of the omentum secondary to pathological conditions of other intraperitoneal organs are, of course, frequent while strangulation and thrombosis secondary to torsion are not uncommon. In a paper entitled "Primary Acute Epiploitis," Eliason and Johnson reported thirteen cases, ten of which involved the greater omentum and in all of which torsion was the causative factor. Strangulation and thrombosis secondary to omental torsion give an

entirely different gross appearance than idiopathic infarction does, and having once seen both for comparison one is not likely to confuse them. It should be remembered that omental torsion is more likely to occur in thin omenta with scanty amount of fat because this type of omentum is more easily twisted.

In the two cases here reported each presented an infarct of a localized, distal segment of the greater omentum. In neither case was there co-incident intraperitoneal pathological conditions. Neither case was associated with torsion of the omentum nor was there a history of antecedent violence which could implicate external trauma as an etiological factor.

It was observed that while neither individual was obese the omentum in each instance was thick and fatty. Whether the large amount of fat present in the omentum, in each of these cases, was of etiological significance or merely co-incident is difficult to say. It was, however, in marked contrast to those cases of omental torsion in which the omentum has been thin with a scanty amount of fat. Pines and Rabinovitch suggest that stretching of an omental vein consequent to trauma leads to the formation of a thrombus.

From a consideration of these two personally observed cases the following is offered as a possible explanation of the etiology of the condition: In view of the close communication between the blood supply of the stomach and omentum it is evident that the strain on thin-walled veins is definitely increased at the time of vascular congestion incident to a full meal. During this period additional strain from increased intra-abdominal tension incident to straining, coughing, sneezing or lifting may be sufficient to cause a primary rupture of the dependent veins of the omentum with hemorrhagic extravasation and secondary thrombosis. E. L. (Case 11) gave a history of heavy work in handling boxes weighing approximately 120 pounds shortly following the noon meal just prior to the onset of pain.

## SUMMARY

A report is given of two cases of primary idiopathic segmental infarction of the greater omentum, emphasizing clinical and pathological features.

Each case, without a history of antecedent violence, presented an infarct of a localized, distal segment of the greater omentum not associated with omental torsion and characterized by an absence of any co-incident intraperitoneal pathological condition.

An explanation is suggested with regard to the etiology of this condition.

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THE most effective stimulus for intestinal secretion is the entrance of pancreatic juice into the intestine. It is possible that secretin, known to have a controlling influence over the production of pancreatic juice, also acts directly as a stimulus to the secretion of intestinal juice.

From—"Surgical Physiology"—by Joseph Nash (Charles C. Thomas).



# ULCERATING CANCER OF BREAST AS A PORTAL OF ENTRY FOR FATAL TETANUS

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## CASE REPORT

MRS. L. B., age sixty-seven, was first seen on the morning of her admission to the Memorial Hospital of Greene County at Catskill, New York, September 3, 1941, complaining of severe stiffness of the jaws. Her past history revealed that in November, 1940, the patient had noticed a mass in the right breast but did nothing about it. In April, 1941, it became ulcerated and the patient used herbs, grasses and all kinds of salves, but it failed to improve. Two days before admission, she became somewhat toxic and had a slight fever and sore throat. Then the stiffness of the jaws developed and she sought medical advice. The family history and past illnesses were irrelevant except that the patient's husband had died four years previously from cancer of the large intestine.

Physical examination showed a well developed, rather thin adult white female, height about five foot three inches, weight about 130 pounds. The facial expression showed a characteristic so-called "risus sardonicus." The skin was clear and there was no rash. Mucous membranes were of fair quality. Mental orientation was good and mental status clear. Blood pressure was 140/60; temperature was 99.8°F. rectally. The pupils reacted rather sluggishly to light and accommodation but were equal. A congenital cleft palate was present for which an occlusion dental plate had been fitted. This was removed with difficulty because of marked trismus of the patient's jaws. The septum was markedly deviated, allowing poor ventilation through the left nostril. The right was adequate. With difficulty the throat was examined and showed no inflammation, but was filled with mucus. There was moderate cervical gland enlargement and some enlargement of the lymph-nodes in the right supraclavicular area. The right breast showed a large ulcerating cancer about the size of a large fist starting at a point directly above the nipple and extending to the right axillary and pectoral muscles. The right axillary lymph-nodes were also enlarged

*en masse* to about the size of an orange. The skin over the right breast, which did not ulcerate, had a pig-skin type of appearance with associated edema. The edges of the ulcerating area were sharply margined and indurated. The crater of the ulcerating area did not bleed easily and was covered with a thick film of powder which the patient had recently applied. As mentioned in the history, there had also been applied many household remedies, various herbs, grasses and salves.

The patient had concealed this cancer from the daughter with whom she lived, for the past year, covering the discharging area with any cloth or material she could most conveniently obtain. The left breast showed no involvement. The heart sounds were distinct, of fair quality and regular. No murmurs were heard and no adventitious sounds. The breath sounds were vesicular throughout, except for an occasional râle in the left posterior chest at the base. There were no definite areas of dullness due to consolidation on percussion.

X-ray examination of the chest, however, taken on September 4, 1941, by Dr. William M. Rapp, roentgenologist, on the day following admission to the hospital, showed "areas of consolidation in both lungs, the greater in the lower lobe of the right lung. There was an increase of the transverse diameter of the heart, the right auricle particularly being enlarged. The right diaphragm was elevated and the dome was irregular in outline. In the lateral view of this chest wall there were distinct mottlings of the right breast." There was no gross deformity of the extremities. The reflexes appeared to be hyperactive, but there were no abnormal reflexes such as Oppenheim or Babinski; however, there was a moderate degree of opisthotonus associated with a definite Kernig reaction. There was some slight abdominal distention, but no rigidity of the abdominal musculature. No tender points or masses were detected abdominally or rectally. The blood count showed a leukocytosis of 12,000, with 85 per cent polymorphonuclear leukocytes. Spinal tap gave a clear fluid not

under increased pressure, with a normal cell count. The Wassermann test was negative. The temperature varied between 100° to 102°F. until terminally when it rose to 104°F. Marked dysphagia occurred associated with cyanosis. The patient was given 60,000 units of tetanus antitoxin intravenously and 20,000 intramuscularly in the course of two days. Oxygen and intravenous glucose and saline, sulfathiazole and other supportive measures were used without avail and the patient expired on the third day after admission. Convulsive seizures were controlled by intravenous pentothal. Intramuscular sodium luminal was also found to be helpful. Permission for autopsy was obtained and performed by Dr. John J. Marra, and the findings were as follows:

#### GROSS DESCRIPTION

The body was that of a fairly well developed, well nourished white female having a body length of 155 cm. and weighing approximately 130 pounds. There was no edema. Postmortem rigidity was present in the upper extremities. Lividity was slight and dependent. The pupils appeared somewhat unequally dilated, the left being more contracted than the right. Arcus senilis was present. The ears and nose were negative. The jaws were rigid. A few carious teeth and a cleft palate were present.

In the right breast in the right upper outer quadrant there was a large oval, fungating, ulcerating area measuring about 6.5 cm. in diameter and having an ulcerated floor about 3 cm. from the surface. The edges of this mass were rolled, indurated, reddish in color and the entire mass was firmly adherent to the surrounding breast tissue. The right axillary lymph-nodes were also enlarged and appeared to be replaced with neoplastic tissue. The tumor mass in the breast was firm, greyish in color and extended into the breast tissue for a depth of about 5 cm. There were numerous pigmented lesions over the abdominal portion of the skin.

In the peritoneal cavity no fluid or adhesions were present. The peritoneum was dry and sticky. The diaphragm reached the fourth rib on the right and the fifth interspace on the left. The liver edge was at the costal margin. The appendix was free and normal.

There was about 15 cc. of clear, serous fluid on each side in the pleural cavities. The trachea was in the midline and the great blood vessels showed nothing unusual. The pericardial cavity was not remarkable grossly.

The heart appeared to be of normal size. The coronary vessels showed a slight amount of intimal thickening. The myocardium was pale

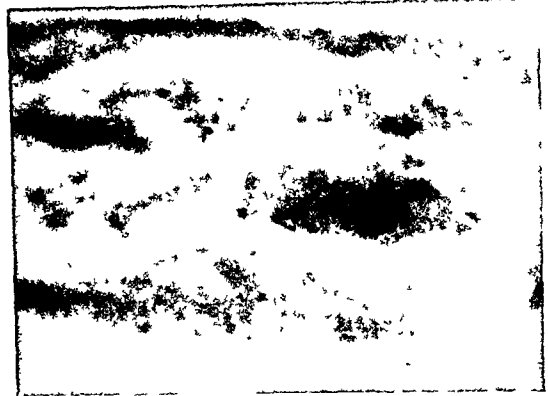


FIG. 1. The dark racquet-shaped bodies represent the organism, *Clostridium tetani*, in a section of tissue taken from the breast cancer, stained by Gram-stain method for fixed tissue. (Microphotograph; oil immersion objective; magnification  $\times 1,000$ .) (Photograph and slide by Dr. John J. Clemmer.)

and tore readily. The thickness of the right ventricle was 0.6 cm. and that of the left 1.4 cm. The valves appeared normal, grossly, and had normal dimensions. The endocardium was smooth.

In the aorta there were a few atheromatous plaques present.

The lungs were both dark reddish in color, wet, heavy, and somewhat firm. The bronchi contained much frothy mucoid material. Sections showed marked congestion and edema. The left lung, especially, showed purulent material on pressure. There were a few foci of atelectasis in the lower lobe. In the region of the right apex, the lung parenchyma was discolored, somewhat firm and with pressure a purulent exudate exuded. The lung parenchyma was barely visible in this area and gave the appearance of beginning abscess.

The spleen measured 7 by 4 by 3 cm. It was flabby and sections showed a dark reddish-brown, granular cut surface, from which a reddish, paint-like material could be scraped. The gastrointestinal tract showed considerable distention with gas. The pancreas was not unusual grossly. The liver appeared to be of normal size, measuring 22 by 14 by 8 cm. The capsule was smooth and sections showed a mild amount of congestion with a beginning nutmeg appearance.

The gallbladder was distended with bile, and upon opening, there was found about nine small faceted, biliary stones, the largest measuring

about 0.5 cm. in diameter. The wall of the gallbladder was of normal thickness and showed nothing unusual. The ducts were patent and free of stones.

The adrenals revealed nothing grossly. The kidneys measured 10 by 7 by 4 cm. each. The capsule stripped with some difficulty and left a greyish-pink, somewhat granular surface. There were a few scarred areas noted grossly. Sections showed a fairly well demarcated cortex and medullary portion. The cortex measured about 0.4 cm. in thickness. The pelves, calices and ureters were not remarkable grossly.

The urinary bladder contained about 50 cc. of cloudy urine. The ovaries were atrophic, but otherwise not unusual. The uterus was small and the endometrium thin. The cervix showed nothing unusual.

*Provisional Anatomical Diagnosis:* Tetanus (clinically); diffuse, ulcerating adenocarcinoma of the breast with extension to pectoral muscles and pectoral fascia; metastases to right axillary lymph-nodes; diffuse bilateral bronchopneumonia; chronic cholecystitis with cholelithiasis; general arteriosclerosis, mild; congestion of visceral organs; dehydration.

*Microscopic Examination. Heart:* The epicardium contained a few small hemorrhagic areas. The myocardial fibers were fragmented, swollen, granular, and striations were barely visible in some zones. The muscle was edematous and congested.

*Bronchus:* The mucosa was eroded. The submucosal zone was edematous and infiltrated with many leucocytes, most of them were lymphocytes.

*Lungs:* Sections from all the lobes showed the capillaries to be engorged. The alveolar spaces contained much edematous fluid, and scattered about were numerous macrophages containing a dark brownish, granular pigment. Scattered about in all sections were large zones showing distention of the alveoli with a fibrin network packed with leucocytes, all of which were polymorphonuclears. In the sections taken from the right apex, the process had destroyed some of the alveolar walls to such an extent that small miliary abscesses had formed.

*Spleen:* The pulp was fragmented into small islands in some zones. The sinusoids were congested. The Malpighian bodies were not remarkable. The arteriolar vessels showed extensive hyalinization.

*Pancreas:* There was some inter- and intra-lobular fatty infiltration.

*Liver:* The sinusoids showed engorgement. There was mild vacuolization of the liver cells. The periportal tissue showed some phocytes, with an occasional polymorphonuclear and eosinophil.

*Adrenals:* These showed no pathological changes of note.

*Kidneys:* The vessels were engorged. The glomerular capsules showed some fibrous thickening. The tubular lining cells were swollen, granular, and some were desquamated. The lumina contained debris, and an occasional one showed plugs of purplish staining granular debris.

*Urinary Bladder:* Showed no pathological changes of note.

*Uterus:* The endometrium was atrophic and showed a few cystic glandular spaces.

*Breast:* Sections from the breast showed columns and plugs of moderately hyperchromatic epithelial cells. The cells varied considerably in size and shape. Some were multinucleated and mitotic figures were scarce. The cells formed a typical glandular structure. The atroma was made up of pale collagenous tissue. The neoplastic tissue reached the overlying skin and part of the skin was replaced with tumor tissue. The ulcerated portion of the tumor showed much necrosis and leucocytic infiltration. The tumor tissue invaded the underlying pectoral muscle, and sections from axillary lymph-nodes showed replacement by metastatic tumor. Special stains from the tumor tissue revealed typical tetanus organisms and their spores. With Gram-stained tissue, the latter took the form of short rods with terminal globular formations appearing as typical racket-shaped forms. (Fig. 1.)

*Report by Dr. John J. Clemmer.* "From the gross and microscopic studies, this individual presented several interesting phenomena. The lesion in the right breast was a slowly growing adenocarcinoma with regional metastases. Marked ulceration and inflammation occurred in the central portion of the tumor. Numerous cultures taken from the necrotic portions of the ulcerated area failed to give growth of *Clostridium tetani* or its spores. This was not unexpected since it is difficult to grow these organisms from tissue (B-41-5598). However, special stains on the breast tissue itself revealed the presence of these organisms and their spores.

"It was difficult to evaluate the specific immediate cause of death. The diffuse bilateral bronchopneumonia with accompanying lowered

oxygen exchange and deficient oxygenation of the blood could have produced death. Most likely factors were a combination of both processes.

"The gallbladder findings were incidental and probably had no significance in the causing of death.

"*There are no specific pathologic findings in tetanus infections.*"

The literature on the subject of tetanus does not mention a proved case of ulcerating cancer of the breast as a point of entrance for fatal tetanus. A presumptive diagnosis in this case was made from the clinical course until positive diagnosis was made on autopsy. There are many parts of the world where the soil is particularly rich in tetanus organisms. This is true in general of densely populated areas. Georgia, Indiana, South Pennsylvania, South California and the Hudson River Valley are said to be particularly well provided with tetanus rich soil. Exposure is, of course, an important factor in the incidence of tetanus.

Until recently the fire-cracker celebrations of July Fourth took a yearly toll of lockjaw victims well into the hundreds. Seasonal studies show that lockjaw is commonest in July. However, the summer season is generally favorable to the development of tetanus. External contamination seems to be an immediately responsible factor. The use of shields after vaccination seems to predispose to tetanus infections, probably because the parents or children keep these shields on or reapply them after they have become dirty and contaminated. Surgical operations, especially those in the fields of proctology, gynecology and urology may be followed by tetanus. Usually in these cases, fecal contamination has occurred either in the operating room or in the ward, very often from the incidence of patients transferring fecal material from the anal region to the surgical wound area. Tetanus organisms are not often found in the human rectum, but when they are there, the eating of uncooked vegetables is considered to be the cause.

Age appears to be a predisposing factor.

Most susceptible periods are immediately after birth and early middle life. In some cases lockjaw developed and no wound could be discovered. In this so-called idiopathic type, intestinal infection is probably the responsible agent, unless a microscopic abrasion can be considered responsible, as in this case, the patient undoubtedly infected herself directly by a dirty cloth of tetanus infected material applied to the ulcerating cancer. The bacillus of tetanus is very resistant and in dried pus or spore form it survives most of the common antiseptics. As mentioned by Dr. Clemmer, there are no typical morbid factors in tetanus, the nerve cells show degenerative lesions and there are often minute hemorrhages in the brain and cord. Tetanus of the newborn is about 100 per cent fatal and in adults the general consensus of opinion is that it is about 80 per cent fatal.

#### SUMMARY

An unusual case of ulcerating cancer of the breast as a portal of entry for fatal tetanus with *autopsy* proof of the organism spores found in the wound is described and discussed. No similar proved case is found in the literature.

I wish to express my thanks to Dr. John J. Clemmer, Director of Bender Laboratory, Albany, New York, for his kind co-operation in obtaining the slide prepared from the cancer tissue, and microphotograph as illustrated.

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# SLOUGH FOLLOWING INJECTION FOR HEMORRHOIDS

## CASE REPORT

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THE injection treatment of hemorrhoids is now a generally accepted method of therapy for this condition. It was formerly looked down upon inasmuch as "quacks" used this method originally and introduced it to the profession. In this paper, we are not going to deal with the merits or demerits of this form of therapy; but merely want to call to the attention of fellow-practitioners that this form of therapy carries with it many dangers.

The greatest danger lies in the fact that the injection method seems so easy that many, with no particular knowledge of rectal complaints, start treating patients by this method, and, in consequence, bring about many complications which tend to bring this method of treatment into disrepute.

Only simple uncomplicated internal hemorrhoids should be given a trial by this method. External hemorrhoids should never be injected, nor should internal hemorrhoids be injected if accompanied by other anal or rectal pathological conditions.

The literature is filled with articles on this form of therapy and carries only the good reports. There are very few papers and few textbooks which go into detail on some of the serious complications which might arise following faulty injection treatment for internal hemorrhoids. The injections should be made beneath the mucous membrane overlying the hemorrhoid, preferably above the hemorrhoid but not into it. Only by experience can one judge how much of the sclerosing solution should be injected. The two solutions now most universally used in this method of treatment are a 5 per cent solution of quinine

and urea hydrochloride and a 5 to 10 per cent solution of phenol in vegetable oil. If properly given, injection therapy carries with it very little if any discomfort to the patient.

At this point, it might be mentioned that only about 25 per cent of all cases of hemorrhoids are suitable for injection treatment, and it might be added that recurrences will take place right along in those cases which were not originally properly selected for this type of therapy; in other words, if treatment is instituted in a case in which there is any reasonable doubt that the treatment will not be successful, there is no question in my mind but that case will have a recurrence.

The various complications that arise are:

1. Abscesses occur very rarely. The author himself has been very fortunate not having any as yet. Morgan,<sup>1</sup> of San Francisco, recently reported a case of severe abscess formation with destruction of the entire anus as a result of infection following an injection of internal hemorrhoids.

It is altogether possible that a pyelophlebitis may follow an injection for hemorrhoids; no doubt this condition would cause plenty of toxicity; and it is very possible that this is what took place in the case I am to report. Several years ago, a patient who was being given injections suddenly developed a liver abscess, and it was readily concluded that the injections caused the abscess, the infection being carried through the blood stream from the hemorrhoidal veins to the portal circulation.

2. Rosser and Wallace,<sup>2</sup> of Dallas, reported several cases of oil tumor formation following injection of hemorrhoids with oily solutions. They also reported cases of

stricture formation as a result of extensive fibrosis of the anal canal caused by injections. I have under my care at present a man who has two large anal polyps which are the result of injection of large internal hemorrhoids which never should have been injected.

3. If the injection is given too low in the anal canal, pain will follow, especially if the injection is given within the region of the sphincters.

4. Edema of the anal tissues may follow if the injection is given too low in the anal canal.

5. Sloughs will occur as long as hemorrhoids are injected. The author does not believe there is a proctologist anywhere who at times has not had a slough following an injection. The causes for the slough and subsequent hemorrhage are: (1) too superficial injection for the hemorrhoid; (2) the injection of too much solution causing a depletion of the circulation to the mucous membrane; this is then followed by sloughing of the mucous membrane and at times hemorrhage which may be slight or quite serious. It makes very little difference as to the type of solution used, as these complications will arise now and then when the injection is not properly given. Sloughing may bring about quite a toxic condition as it did in the case about to be reported.

#### CASE REPORT

On June 6, 1939, Mr. T. R., age thirty-four, was seen at his home. The patient was in distress, had a cold sweat, a temperature of  $101^{\circ}\text{F.}$  and was complaining of severe pain in the rectum. He stated that on May 29, 1939, he started to have rectal bleeding; he consulted a physician who prescribed a salve which did not stop the bleeding; on May 31, 1939, he was given an injection which not only did not stop bleeding, but caused considerable pain. The physician left town, and, on June 3, 1939, he went to "one of those places" where he was given a "real shot" to cure him, and this injection caused such severe pain that he remained bedridden up to the time I saw him.

Examination revealed the patient to be in great distress, with a temperature of  $101^{\circ}\text{F.}$ , cold sweat, and a general appearance of being

quite toxic. A rectal examination was done under great difficulty, and a large sloughing area was felt in his right posterior quadrant of the anal canal and rectum. Needless to say, this examination caused the patient considerable pain. Hot sitz baths and sedatives were prescribed, but on the next day the patient was no better and was hospitalized. On June 8, 1939, under sacral anesthesia he was operated upon. At surgery, a large sloughing mass about three inches in diameter was found in the anal canal and rectum extending from a point one inch above the anus and situated in the right posterior quadrant of the anal canal and rectum. There were some very much indurated hemorrhoids on each side of this sloughing area. The hemorrhoids were excised with the cautery and the posterior commissure was incised to provide good drainage for the sloughing area. The rectum and anal canal were then packed with iodoform gauze.

On June 9, his temperature went to  $103^{\circ}\text{F.}$ , and the patient was quite uncomfortable. On June 10, the packing was removed, and later in the day, there was considerable bleeding from the rectum. Examination that afternoon revealed the patient in moderate shock. Rectal examination revealed bleeding from the sloughing area and the rectum was again packed with gauze his condition continued to improve until June 13 when he again started to bleed. Repacking did no good and he continued to bleed. On June 14 he was given 1,000 cc. of 5 per cent glucose intravenously and the rectum again packed with gauze. This did not stop the bleeding and on June 15 he continued to pass clots, looked very pale, and was perspiring freely. He was given 500 cc. of blood. On June 16 the patient continued to bleed and he was again given a transfusion with 550 cc. of blood. That same evening he was taken to surgery, where, again it was found the bleeding was coming from the center of the sloughing area seen at the previous operation, and a suture was put through this sloughing and bleeding area (with a prayer that it would hold) and the rectum packed with iodoform gauze, with a tube in the rectum to allow for the escape of gas. The next day he was much better and this improvement continued. On June 23 he was given a transfusion of 250 cc. of blood. The daily improvement was so marked that he was discharged from the hospital on July 4, 1939. He continued to improve, the wound kept on healing, and he was discharged from my care

on July 17, 1940, when the rectal wound was examined and found to have healed perfectly.

To give one an idea of how much bleeding took place in this case the blood counts have been tabulated as follows:

BLOOD COUNTS

Date	Hemoglobin	Red Blood Corpuscles	White Blood Corpuscles
6-7-39	78	4,160,000	12,000
6-10-39	73	3,610,000	13,400
6-11-39	72	4,050,000	15,700
6-13-39	62	3,350,000	
6-15-39	Transfusion	500 cc.	
6-16-39	45	2,310,000	
6-16-39	Transfusion	550 cc.	
6-21-39	56	3,190,000	12,000
6-23-39	Transfusion	250 cc.	
6-24-39	59	3,410,000	11,600
7-1-39	64	3,700,000	

## CONCLUSION

Injection therapy treatment of hemorrhoids carries with it some danger. Care must be taken in selecting the cases for injection treatment, and still further care must be observed in the administration of the injection. Further, those cases in which injections are being given must be watched very carefully so that any complications that may arise will be taken care of immediately.

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# New Instruments

## A NEW BITING CYSTOSCOPE\*

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THE purpose of this paper is to describe an improved form of biting cystoscope, designed to eliminate the shortcomings of those in current use.

No. 20 F. gauge and is curved to facilitate insertion into the bladder. At the terminal end of the sheath there are two jaws, whose biting surfaces may be shaped to suit their

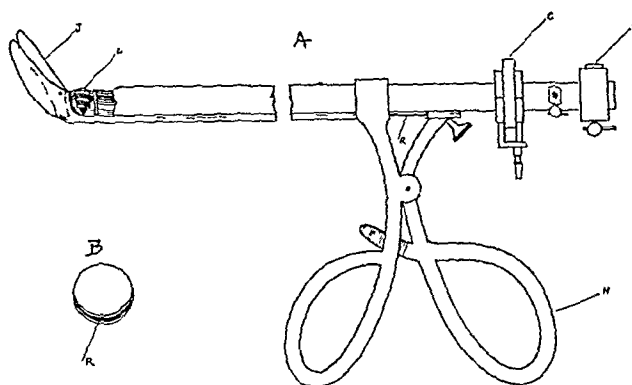


FIG. 1. A, schematic drawing of new biting cystoscope sheath. The jaws, J, are controlled by scissor handles H, but a brake handle may be substituted for this manipulation. L, lamp at right angles to longitudinal axis of sheath and adjacent to fenestral opening. R, thin wall rod of crescent-shaped cross-section, connecting handle with jaw. C, electric coupling. O, combination locking device and stopcock. B, cross-section of lumen of sheath. R, position of crescent-shaped rod in lumen of sheath. Note ample room left for telescope, etc.

The Buerger operating cystoscope, as well as those of Ravitch, Young, Lowsley, McCarthy and others, have one or another of the following shortcomings: (1) In all of them, the gauge of the sheath is too great. (2) It is difficult to introduce into the bladder because it is not curved. (3) Illumination and vision are limited, and are quite shut off when the jaws of the instrument are closed. (4) There is a lack of means for continuous irrigation.

The instrument I have designed, shown in the accompanying illustrations, has a

specific purpose: cutting, grasping, breaking, etc. The distal jaw is stationary, while the anterior jaw is movable. Its action is controlled by a thin-walled steel rod of a crescent-shaped cross-section which moves within a guide of similar form in the sheath. This rod, made of sheet metal, will not buckle even under great pressure at the handle.

For illumination, there is a lamp adjacent to the fenestral opening, approximately at right angles to the longitudinal axis of the sheath. By this arrangement, the lamp and

\* Read at the Beth David Hospital Clinical Conference, November 17, 1941, New York City.



the fenestral opening are brought close to the biting jaws, affording unobstructed vision and continuous illumination.

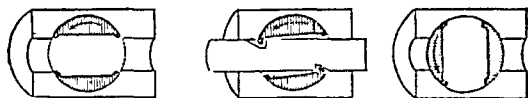


FIG. 2. Cross-section of combination locking device and stopcock of Figure 1-o; left, stopcock open; center, stopcock locking telescope, obturator, etc., to sheath; right, lumen of sheath completely closed.

There is enough space left within the sheath of the cystoscope to permit the introduction of a No. 14 F. observation telescope for vision. At the sides of the

mouth end of the sheath there are two stopcocks for irrigation. The locking device (Figs. 1 and 2) o, is of my own design. It can hold the component parts as a single unit, or act as a stopcock.

The advantages of this instrument may be summarized as follows: (1) It is of smaller gauge than those now in use. (2) It is as easy to introduce into the bladder as the nonoperating cystoscope of the same gauge. (3) It allows continuous irrigation. (4) It operates with facility under good illumination and full vision. (5) It has a simple combination locking device and stopcock.



THERE are certain contraindications to the use of the gastroscope. It should not be employed in the presence of esophageal disease such as carcinoma, diverticulum, stricture, or varix, nor in cases of aortic aneurysm and cardiac decompensation.

From—"Carcinoma and Other Malignant Lesions of the Stomach"—by Waltman Walters, Howard K. Gray and James T. Priestley (W. B. Saunders Company).

# A BED FOR HOME OBSTETRICS

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THE practice of domiciliary obstetrics deserves careful consideration. Many deliveries, by necessity, must still be quite satisfactory. It is inexpensive, easily and quickly demountable, looks like an ordinary bed and gives the obstetrician all

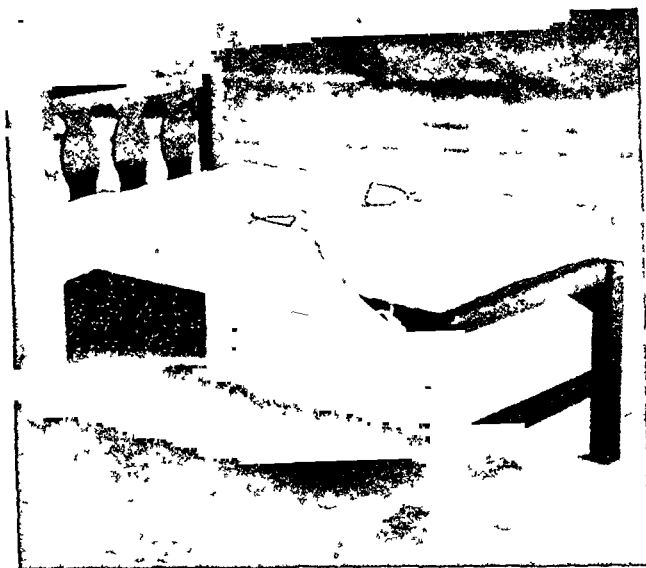


FIG. 1. Bed for home obstetrics.

conducted outside of hospitals and often in homes with small and inconvenient rooms, in small towns and on the farm where hospital facilities are not available.

The economic status of the prospective mother affects her well being and the safety with which she may expect to pass through the experience of giving birth. The relative safety of delivery at home is apparent. To further this safety and to give women whose economic situation will not permit adequate hospital care the best service possible under the circumstances prompted me to develop a bed for labor and delivery for the home. This bed serves both as a delivery bed and also as a lying-in-bed; this bed, since it is intended to replace the ordinary low bed usually found in homes, is simple to operate, light to facilitate transportation and comfortable to the patient. This type of bed has now been in use for more than six years and has proved

the practical operative positions necessary for home delivery practice. There is nothing about the appearance which may give the expectant mother any fright.

This bed gives the full length horizontal position and the short delivery position. If it is desired to have the perineum of the patient extend out beyond the end of the bed in operative position, this can be obtained easily. Thus plenty of room is given for the use of instruments, needle holders, retractors, etc., in repair work. The patient's legs usually are steadied by nurses but if it is desired to use leg holders adjustable mountings are provided into which these may be inserted. Tractor straps of heavy sash cord, adjustable to shorten or lengthen the hand hold, are supplied with comfortable grip handles. The tractor cords fit securely into holding lugs on the side of the bed frame.

A Simmons link fabric spring and a good quality felt mattress is used. This gives the much desired firmness so essential in operative work.

The frame is of seasoned oak construction, attractively stained and varnished so as to harmonize with the average household furniture; it is washable and is mounted on sliding furniture shoes. The total length is seventy-four inches, total width thirty-six inches and the total height including the mattress thirty-six inches.

This bed has served most satisfactorily. The nurses like it and patients say it is very comfortable. After the delivery, the sheets

are changed, and the patient is made comfortable. The patient uses this bed for about two weeks and then replaces it with her usual bed.

Our local furniture dealers carry these beds and rent them to the patients for a small fee. They are usually taken to the patient's home, at some convenient time before the expected confinement date, and are set up. A number are always available. We have five in circulation now. With these special beds and with our sterile packs which we prepare, we are endeavoring to render a good obstetrical service in a rural district in Missouri.



A RETENTION cyst is sometimes found in the under surface of the tongue near the tip. This lesion is due to dilatation of the gland of Blandin or Nunh, which is found beneath the tip of the tongue.

From—"Pathology of the Oral Cavity"—by Lester Richard Cahn (Williams & Wilkins Company).

# COMBINATION NEEDLE HOLDER AND SUTURE SCISSORS

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THE purpose of this combination needle holder and suture scissors is to eliminate the unnecessary handling of

This instrument consists of the usually shaped needle holder with the distal halves of the jaws being the needle holding por-



FIG. 1. Photograph of a carved model of the instrument.

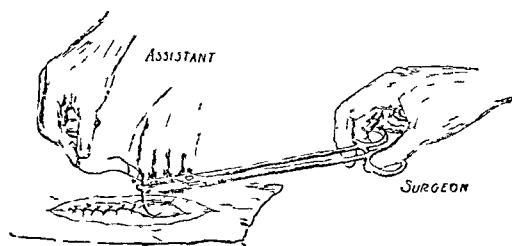


FIG. 2. The surgeon inserts the needle between the needle-holding jaws and places the suture.

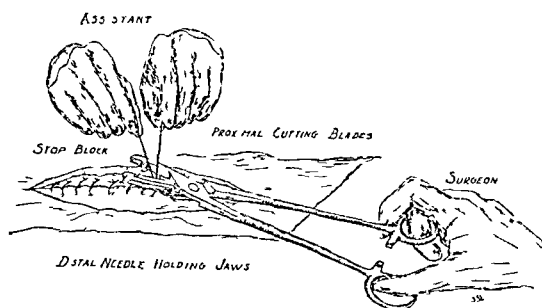


FIG. 3. The assistant, having tied the suture, holds the ends of the suture while the surgeon severs the ends.

the needle holder and suture scissors when the latter two are used as separate instruments. This instrument will eliminate that methodical maneuver of laying down the needle holder and grasping the suture scissors each time the tie is completed. It will also eliminate those infrequent but distressing instances in which the suture scissors is misplaced on the instrument tray or about the surgical field.

tion and the proximal halves, those nearest the lock, converted into the scissors. (Fig. 3.) Between these two halves is a stop-block on the one jaw and a corresponding notch on the other jaw. This stop-block has a two-fold purpose: First, it is to prevent the needle from being placed between the

scissors portion, and secondly, when a double suture is being used it catches one thread of the double suture and allows the other thread to pass over the blade of the scissors to be cut.

When an assistant to the surgeon is present, the surgeon places the suture. (Fig. 2.) The assistant then ties the suture and the surgeon severs the suture ends. (Fig. 3.)

When an assistant to the surgeon is not present, for example when repairing minor lacerations in the emergency room or in the office, or in the delivery room repairing episiotomies or obstetrical tears, the suture can be placed and tied by means of the distal portion of the jaws and the suture cut by the proximal blades without the use of another instrument.



ALTHOUGH ether is now administered most frequently from the gas machine in combination with oxygen and one of the anesthetic gases, its usefulness when administered by the open or semiopen drop method should not be overlooked.

From—"Carcinoma and Other Malignant Lesions of the Stomach"—by Waltman Walters, Howard K. Gray and James T. Priestley (W. B. Saunders Company).

# A MODIFICATION OF THE METZENBAUM SCISSORS FOR GENERAL SURGERY

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A FEW years ago, while visiting at the Lahey Clinic in Boston, we were impressed by the Metzenbaum scissors (Fig. 1, No. 1) used by the general inflammatory tissue was dissected these scissors would spring and not cut. This was due largely to the light construction around the screw and in the shank.

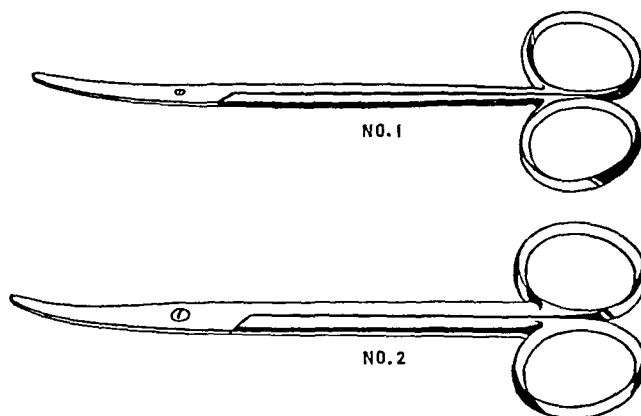


FIG. 1. 1, Original Metzenbaum scissors; 2, modified Metzenbaum shears. The cutting blades are heavier and there is an obvious increase in the metal around the screw and shanks.

surgeons. Seeing the ease and facility with which these instruments were used we secured a pair, and in our own hands this instrument was an improvement over the more cumbersome, more commonly used heavier dissecting scissors.

After using these Metzenbaum scissors for a few years certain weaknesses became obvious. For example, if tough or firm fibrous tissue was incised, or if scar or thick

We have devised a modification which includes thickening of the metal around the screw and shank. (Fig. 1, No. 2.) We have used these new shears for some months and they are most satisfactory. All the advantages enjoyed with the lighter scissors were saved, and the added strength and cutting power have increased their usefulness and adaptability.



# AN INSTRUMENT FOR THE SPINAL SUBARACHNOID INJECTION OF IODIZED OIL

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THE use of iodized oil for the diagnosis of spinal lesions has again become prevalent due to the attempts to

soldered to the other end. The coil in the silver wire permits sufficient movement without displacement of the needle in the

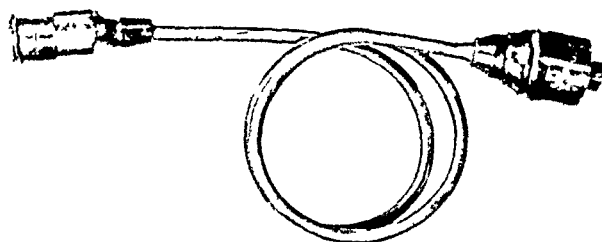


FIG. 1. This coiled tube acts as a spring.

diagnose more accurately a ruptured intra-vertebral disc. It has always proved somewhat troublesome to inject this substance into the spinal subarachnoid space because of the viscosity of the oil. It is for this reason that the following simple apparatus was designed.

This apparatus consists of a Luer-lock adapter, soldered to one end of a coiled silver wire and an ordinary needle adapter

spinal canal when pressure is exerted upon the syringe. The Luer-lock of the syringe is attached to the opposite end. When the oil is heated and injected in this manner, there is no danger of disconnecting the system. After the injection the stylette is replaced before the withdrawal of the needle to prevent the globules of oil infiltrating into the muscle.



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# Bookshelf Browsing

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LANFRANCO

INCUNABULA MEDICA VI

FELIX CUNHA, M.D.

SAN FRANCISCO, CALIFORNIA

LANFRANCO was born in Milan of a fairly well-to-do family. His schooling consisted of private tutoring until the age when it was considered that he was ready for the University at Bologna. Here he expressed his desire to study medicine which fitted in well with the family plans as the social status of a family of those times was materially enhanced if their sons were engaged in either the professions of law or medicine.

As an above-average student he attracted the attention of William of Saliceto, one of his teachers, and upon receiving his medical degree, was given the opportunity of acting as a general assistant in William's surgery and in taking on junior duties as a teacher at the University. For a while he followed this path, but on deciding that he wished to see more of actual bedside activity he went to Milan and practiced there until the year 1290.

Here he incurred the displeasure of one of the powerful families of Milan who in retaliation so engineered matters that Lanfranco was banished from Milan and forbidden to practice either medicine or surgery there. There being nothing more promising to do he returned to Bologna and once again took up his work of teaching and of assisting Saliceto.

After a short period of this work he again became restless and unhappy; therefore, he decided to seek new opportunities in other lands and journeyed to France to the city of Lyons.

Practice here never attained the point he

had expected it to either materially or intellectually, so he put his idle time to use by writing a "Chirurgia Parva" which he hoped would be used by his sons in later days. Despite his own setbacks and disappointments, he wished that his sons should follow in his footsteps, study medicine and then devote themselves to surgery. With this thought in mind he hoped to condense into this "Minor Surgery" that which he had found of value in the works of Hippocrates, Galen, Aristotle and the Arabians headed by Avicenna, not failing in the least to give due credit and attention to his teacher and master, Saliceto.

The restlessness which was part of his makeup carried him into many of the provincial towns of France, usually in the neighborhood of Lyons, but as a practitioner of medicine in a small locality he was evidently to experience only failure. Finally; in 1295, he was to reach Paris. Here he was to attain considerable success not only as a surgeon but as a teacher of surgery in the University of Paris.

His instruction had its appeal in that it was real clinical teaching, bedside diagnosis, stressing accuracy in diagnosis, which at that time was a novelty not only in the school at Paris but in all the existing medical centers. He insisted that all cases be studied thoroughly, completely, and that all surgeons should be well grounded in clinical medicine. By this insistence he did much to raise the standards of French surgery and the status of the French surgeons.



His "Chirurgia Parva" was divided into sixteen chapters under five separate headings. The first part was devoted to a

diseases, nose and throat ailments, kidney and bladder stone, hemorrhoids, blood letting and sexual malformations.



FIG. 1.

description of the qualities necessary for a surgeon. Above all he should be a complete physician; he should recognize the purposes of surgery; and he should possess that idealism so essential to the successful practice of the art. The remainder of this part one is devoted to an anatomy and physiology of the body following out the arrangement of his teacher, Saliceto, devoting each description to a definite region of the body thus keeping it as a topographical anatomy. The second part is devoted entirely to wounds of special parts, and again imitating his teacher, "ad capite ad calcem" (from head to heel) described special surgical anatomy of each part.

The third chapter constitutes a compendium of the general medicine of the time and has the most material if considering the number of pages. It treats of skin

Part four is devoted entirely to fractures and dislocations and their method of reduction, while Part five, follows along an identical line with the "Cyrurgia" of his master, Saliceto, and contains a long list of the more common poisons and the various antidotes for each.

Scattered here and there in this "Chirurgia" were many novelties in methods used and many sound pearls of advice. One in particular, a description in detail of the symptoms of skull fracture with a protest against the too common practice of trepanation in all cases, deserves elaboration. He described the initial state of excessive shock, and states that one of the causes of the high death rate attached is that too many surgeons wish to do a skull trephine when the body is at its lowest point of resistance, therefore, such patients in-

variably die. It was his opinion that trepanation should be reserved for only those cases in which fragments of the skull were depressed causing pressure upon the brain or when the dura covering of the brain was irritated.

As a large number of herniotomies were done by travelling herniotomists, many of whom followed a school of procedure which included castration as a part of the hernia operation, Lanfranco warned that there should be some moderation with regard to this procedure and he advised patients to seek relief by means of a truss and to submit themselves for operation only when all available measures had been exhausted.

His "Chirurgia" became very popular and served to extend his reputation and influence beyond the borders of the Latin world. Many surgeons in other countries, not being sufficiently familiar with Latin, found means of having translations made for their personal use. Most of these translations did not consist of the complete work. Two Hebrew translations were made, one consisting only of the fifth book, the antidotary, which would be very popular and necessary to a general practitioner. One Spanish translation was made of this same book, confirming in a way the popularity of these "Antidotarium." Later an English translation was made of the complete manuscript and was the first anatomical and surgical work to appear in that language. Likewise a French and a German translation was made, all of which indicates the esteem in which the book was held and attests to Lanfranco being a very experienced and wise physician and surgeon.

The manuscript was first printed in Venice in 1490, although an abortive effort was made to publish a French translation in Lyon about 1479. Again its popularity can be estimated from the fact that during the incunabula period of printing four additional editions were printed, all in Venice, in the years 1497, 1498 and 1499.

Because of the political difficulties which at that time beset Bologna, migration of

students and faculty away from this center was to result in the birth of centers elsewhere, where, temporarily at least, partial refuge from war and its attendant dislocations was possible. The height each center was to achieve was dependent entirely upon the intellectual capability of the individual or individuals who were drawn there. Thus Lanfranco chose Paris, and because he brought with him the best of the knowledge and technic of Bologna, coupled with what he had accepted as valuable from the Salernitan school, the University of Paris began immediately its rise to world fame, when students from all over the world flocked there for instruction.

There were two other offsprings of the school of Bologna, each destined in due time to achieve its own place in the intellectual and scientific sun.

Padua, was to become by far the more famous of these two. Driven from Bologna by war and persecution, students flocked to Padua in droves and in a short time it was to be the typical university center, with its "Quartier Latin" and nearby Venice. During its career it was to encounter considerable vicissitudes and its place as a center of learning was maintained only under extreme difficulties. Due to the gangster-like tyranny of one of its leading and controlling families, in its early days it sank to a very low ebb and was revived only by pressure and help from the papacy. It lacked in these early days that one feature which seemed an absolute essential to growth and progress, a personality. Had Lanfranco come to Padua its growth would have been more immediate or spectacular. Padua needed a Lanfranco. For lack of such it was destined to wait almost one hundred years before it should reach its peak of accomplishment and then to succumb to that same ever recurring formula—decline and disintegration into nothing.

Montpellier, in France, was the other daughter of Bologna, born because of political intrigue and persecution making it impossible for Bologna to do other than

succumb and decline. The magnificent law school of Bologna and the greatest law school in the world, where first autopsies were made legal, casting about for a newer place in which to convene, moved to Montpellier. The faculty of arts followed, then finally the medical faculty. With such an abundance of material Montpellier flourished for almost three hundred years before it was to meet with any setback, and then only a temporary one, followed by a renaissance and increase in prestige into the sixteenth and seventeenth centuries. Had Lanfranco chosen Montpellier, there is no doubt that immediately it would have stepped into first rank as the leading center of medical thought and teaching. Montpellier, like Padua, needed also a Lanfranco. Why he chose Paris as the place where he preferred to practice and teach, we do not know; possibly it was the influence of geographical proximity only, having practiced in nearby Lyons and in several of the province towns.

The period comprising the thirteenth century was that in which the great Catholic Orders came into being and acquired immediate and enormous influence. In a relatively short space of time this influence was to metamorphose into control. The Dominicans or Black Friars were founded by Saint Dominic who first conceived the idea of a religious order whose purpose it would be to carry the gospel of Christ to infidel and heretic. The Order was founded somewhere about 1215, and the story of its influence upon all of progress and achievement from that time on has been covered in its many phases by many students and authorities.

Originally, their intention was to be a purely mendicant order. Circumstances or times changed this objective, and they soon began to acquire property and to establish monasteries in strategic areas over the whole of Europe. The first of these was at Bologna, the second at Paris.

Another aim, and a natural one presumably, was the development of centers of learning, universities where a systematiza-

tion of Christian philosophy might be made and taught. In Paris their first efforts were directed toward obtaining a place on the faculty, then the founding of a chair of philosophy, then two chairs, and so on.

In the tremendous strides of their growth, they acquired a tremendous quantity of available manuscripts on the sciences, astronomy, mathematics, law and medicine. Scribes were put to work translating and collecting the available data, but the tragedy of it all is that anything that did not serve their purposes of teaching or was in any way contrary to their own philosophies was destroyed as being of no value. How much was lost by such a process can only be conjectured.

The Franciscan Order, or the Grey Friars, as they were called because of the color of their robes, came into prominence at about the same time. Their theories were entirely different from those of the Dominicans, in fact, almost directly antagonistic. This order made a genuine and honest attempt to adapt a Christian theology to the philosophy of Aristotle and others, even though it disagreed with them in parts.

Both Orders served one essential purpose in man's intellectual progress: They provided shelters or retreats where the more studious could be protected from an outside world when that world became too oppressive or too restricted. Their monasteries provided asylum for those who wanted peace and solitude to think out not only their own problems, but universal problems as well. Possibly that is what we are in need of in our own present day.

These Orders, more particularly the Dominican, first edged in, then took over the centers of research and teaching, finally controlling for some hundreds of years the direction of human thought and effort. In this manner, through able efficient learned personalities, they were to control the direction of medical thought, medical teachings and the start made at

the University of Paris at the time when Lanfranco, greatest Italian surgeon of his day, had brought not only that which constituted the best in Italian surgery, but also all of Arabian medicine and surgery which only a short time previous had been absorbed by the Italian school.

Lanfranco died in Paris in 1308. He and

his work constitute one of those links in the chain of dissemination of medical knowledge. The torch of medical progress passed from the hand of Italy to Paris, in France, from where it was destined to be passed onward again, never faltering, continually going forward, for that is and has been a characteristic of science.



THE early Greek physicians and Galen knew that there were such things as internal cancers, but that is about all they knew so far as one can tell from their writings. They blamed the internal cancers on an excess of black bile.

From—"Carcinoma and Other Malignant Lesions of the Stomach"—by Waltman Walters, Howard K. Gray and James T. Priestley (W. B. Saunders Company).



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